

THE ENGINEERING RECORD

PUBLISHED WEEKLY BY THE

McGraw Publishing Company

James H. McGraw, Pres.
J. M. Wakeman, 1st Vice-Pres.
A. E. Clifford, 2d Vice-Pres.
C. E. Whittlesey, Sec. and Treas.

John M. Goodell, Editor.

MAIN OFFICES:

239 WEST 39TH STREET, NEW YORK.

BRANCH OFFICES:

CHICAGO: Old Colony Building.

PHILADELPHIA: Real Estate Trust Building.

CLEVELAND: Schofield Building.

LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.

United States, Cuba and Mexico.....\$3.00 a year
Canada.....\$4.50 a year
Foreign subscription.....\$6.00 a year
25 shillings, 25 marks, 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGE OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to January, 1907, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of \$2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class Mail matter.

Copyright, 1908, by the McGraw Publishing Co.

The circulation of THE ENGINEERING RECORD for 1907 was 763,000 copies, an average of 14,673 copies per week.

Of this issue 14,250 copies are printed.

TABLE OF LEADING ARTICLES.

Composite-Steel Structural Members.....	653
An Engineer's Criticism of Engineering Education....	653
The Passaic River Pollution Awards.....	654
Conservation of Natural Resources.....	655
Difficult Sub-Surface Building Work in Chicago (Illustrated).....	656
Williamsburg Bridge Towers (Illustrated).....	658
The Cleveland, Ohio, Garbage Reduction Works (Illustrated).....	659
Fire Protection in the New Forrest Theater, Philadelphia, Pa. (Illustrated).....	661
Mill B of the Pacific Portland Cement Company, Con., near Suisun, Cal. (Illustrated).....	662
A Long Ropeway in the Argentine Cordilleras.....	664
The Water-Supply System of Seattle, Wash. (Illustrated).....	665
Electrification of Bavarian Railways.....	667
The Steam Turbine Power Plant of the Pacific Mills (Illustrated).....	667
Some Recent Coking Plants (Illustrated).....	669
Operating Results of the Water Purification Plant at Ithaca, N. Y. (Illustrated).....	672
A Long Rifled-Pipe Line for Pumping Heavy Oils (Illustrated).....	676
The Water-Works System of Ottawa, Kans. (Illustrated).....	678
An Experiment with Calcium Chloride as a Dust Preventive.....	679
A Combination Timber and Concrete Bulkhead (Illustrated).....	680

Composite-Steel Structural Members.

The idea of a composite structural material like two different grades of masonry acting together, or the popular reinforced concrete, is not new, but on the contrary has been realized in structures innumerable. When such a combination includes two fundamentally unlike materials, as steel and concrete, it may be and is adapted most efficiently to engineering structures which have to perform frequently duties of the heaviest character. All this is most fully and effectively illustrated by the many concrete-steel beams, columns and both highway and railway arch bridges, carrying the great loads of high office buildings as well as

those of the heaviest street and railway traffic. There could be no more conclusive evidence of the adaptability of this class of structural members to the most exacting requirements of modern engineering practice. While it is true that this field of composite structural members is now wholly occupied by an intimate combination of the two elements of concrete and steel, so as frequently to make the latter support the former, and without regard to any relation between the two elastic or stretch limits, there is no substantial reason why the combination of two different materials for a single structural end may not be accomplished in some other manner better adapted to the character of other material elements.

With the increasing demand for long-span bridges there must be found structural material adapted to the fundamental requirements of long-span structures. These requirements may be expressed as two, that is, high intensities of working stresses and reduction in own weight, although they are essentially included in the first. Carbon steel has practically been carried to its limit in such heavy structures as the Quebec and Blackwell's Island bridges, and engineers must employ other material of higher resisting capacity in such types of structures for greater spans or even for the same spans, if proper regard is to be had for both safety and economy. Nickel steel, with its high elastic limit and ultimate resistance, is such a material. Improvements in its physical qualities and newer alloys of steel will doubtless yield even better long-span bridge material in the near future. Notwithstanding the comparatively high price of nickel steel at the present time, it becomes the more economic material in consequence of the decreased total amount of metal, compared with carbon steel, in a long-span cantilever, especially if abnormally and unsafely high unit working stresses be avoided for members of the latter material.

If the span be so great and the load so heavy as to exclude carbon steel altogether no question of a composite-steel member can arise, for nickel steel or some similar material must be wholly used. There may be, however, structures of such span and for such loading as to make composite-steel members desirable, if it should prove practicable to form such members. The elastic limit of nickel steel in full-size members may be said to be nearly 50 per cent. greater than that of carbon steel, and about the same relation will exist between the two yield points. The question arises at once, how will two such metals act concurrently, as, for instance, in eye-bars in the same group? Whatever might be the number of eye-bars of each material in the same chord or web member, obviously the actual amount of elastic stretching, when stressed below the elastic limit, must be the same, the intensities of the stresses being directly as the moduli of elasticity. As the modulus for nickel steel is but little different from that of carbon material, the two intensities of stress will be nearly the same. When, however, the elastic limit of the latter is reached it will require but little additional intensity to give a constantly increasing permanent stretch to the carbon steel. When the yield point, slightly above the elastic limit, is reached the material with the lower elastic limit will stretch much without any increase in the intensity of stress in it. The result would be that the nickel steel bars would take all the additional loading until their elastic limit is passed. In other words, the elastic value, so to speak, of the bank or group of composite eye-bars may be taken at the sum of the elastic limits of all the eye-bars in the group. It may be objected that there would not be complete concurrence of action between the two different sets of bars above the lower elastic limit, and that is a question which can only be settled by experimental investigation. It is difficult to realize, however, why the carbon steel bars under such conditions

should not have at least their full yield point value until the elastic limit of the nickel steel bars is passed. If such a group of bars should be pulled to failure, obviously those having the greatest capacity for permanent stretch would break last. In such a composite member, however, working stresses should be assigned wholly in regard to the elastic limit or yield point, the ultimate resistance being a matter of general physical interest only.

A composite compression member of nickel and carbon steels will not give quite the same character of results as tension members, for the reason that the latter remain straight up to failure, while the former are subjected to at least some flexure, which results in considerable deflection if the columns have much length. Furthermore, while some distinct advantage would result from placing the nickel steel in the more remote parts of the section from the neutral axis, the fact that a column probably fails as the yield point is approached limits to a material extent that advantage. Just how far, therefore, this composite cross-section of steel columns can be carried to advantage is less easy to determine than in the case of composite tension members.

Again, there would be distinct advantage in making plate-girder flanges of nickel steel with the ribs of carbon steel, the latter taking the shear and the former the direct stresses of tension and compression. This method of forming a cross-section of plate girders would result in great advantage in heavy, long-span girders, where it is impossible to design the flanges in carbon steel without excessive areas of section.

There is another suggestion which presents itself in connection with the design of this class of composite steel members, of possibly rolling beams and channels with carbon steel webs and nickel steel flanges in cases where the lengths of spans and the loads are large enough to justify the attempt to accomplish such a result. Some of these questions have already been matters of serious discussions among engineers, and it would not be a source of surprise if valuable results should be attained in the near future.

An Engineer's Criticism of Engineering Education.

In an address on the necessity for individual engineering libraries and for continuing study after graduation, Mr. John Lyle Harrington recently told the students of the University of Missouri some very plain truths about what an engineering college course really amounts to as a part of their preparation for a career. Incidentally he gave some sound comments on the common complaint that technical courses are not sufficiently "practical," and as these views are expressed by a man who did not take up engineering work until considerably past the age of most undergraduates, they are worth considering in some detail. So far as the value of the undergraduate course itself is concerned, Mr. Harrington touches the keynote of the matter when he says that graduation is merely a guarantee of a certain training and employers demand it. Only the lowest positions are, as a rule, open to the man who lacks it. It is a pity that a more complete appreciation of this fact does not exist. If a man engages a clerk he expects, as a matter of course, that the clerk has had a grammar school education; if he engages a draftsman or an inspector he expects to secure somebody whose experience qualifies him for the calling; if he engages an engineer he invariably expects the new man to have the education given in an undergraduate technical course. It is a fundamental essential and not something which gives its possessor any advantage over other engineers. In other words, no matter how high the standard of the college, at graduation an engineer's technical edu-

cation is merely well begun, and nobody who does not continue his studies with equal or greater vigor stands much chance to win fame or position. Thoughtful engineers realize that the colleges serve their highest purpose when the whole course is devoted to fundamental studies and only enough practice is taught to illustrate principles. The training that results in the ability to grasp new ideas and in the habit of concentrating the mind upon any matter in interest is everything, Mr. Harrington believes, while the knowledge of a few facts more or less is nothing. This opinion is that long voiced by this journal, and its correctness is shown by the tendency now generally evident to differentiate strongly between vocational schools' teaching "practice" and colleges teaching engineering.

It is plainly evident to those who have an opportunity of hearing the comments young engineers make on their work that they generally think more highly of the chief of a surveying party or the head of a drafting room than of any other member of the engineering corps. They can appreciate what these men are doing, but they cannot understand except very imperfectly what are the responsibilities of the men in the higher positions. At this stage in his career theoretical studies are commonly crowded out of the field of effort of the young engineer, who is inclined to regard his instructors as theorists, who lack practical knowledge and whose opinions must be accepted with caution. These opinions spring commonly from an eagerness for practical work and an unfortunate habit of regarding the theoretical studies pursued in college as a necessary evil, a groundwork to which it will not be necessary to recur once active practice is begun. Unless this opinion is changed not only will the probability of rapid promotion become slight, but a narrowness of working efficiency will result which will restrict the field of possible employment even in positions of small responsibility. Mr. Harrington gives a large number of instances of men who have stagnated because they thought their education was completed when they left college, but only one of his examples need be repeated here, that of a prominent bridge company that needed another designing engineer. It employed about seventy men, substantially all technical college graduates, in its detail drawing rooms. In the course of a few months the chief engineer tested every man of promise among them to see if one could not, in reasonable time, be trained to fill the position, but all so lacked theoretical knowledge or facility in its use that an engineer was obtained elsewhere at twice the salary received by the best-paid man in the drafting rooms. While this is probably an exceptional condition for a large drafting force, it is unfortunately true that the course of instruction in technical colleges does not seem to give sufficient warning to undergraduates of the danger they run if, after their school days, they fail to keep up their studies.

The change between the educational methods of college and the exactions of independent study is so great that young men should be cautioned against considering it a bar to systematic self-education. At college there is a staff of experienced instructors and elaborate apparatus to make clear all questions; a course of study is laid out in great detail, carefully adapted to the average student's needs; there is plenty of time for study, and the rivalry of the classroom spurs on all students. The study done after graduation must be planned by those who will follow it rather than by experienced instructors; there will be nobody to give help, and the time for it must be taken from the hours most people give wholly to rest and recreation. This sounds rather discouraging, but Mr. Harrington points out clearly that by really utilizing a comparatively small amount of time regularly each day a considerable amount

of study can be done in a year, without intruding seriously on recreation and social duties. Every engineering subject is now covered by numerous textbooks, of more or less thoroughness, so that it requires simply perseverance and concentration of mind to carry out a course of study on a subject. To secure breadth of view Mr. Harrington advises turning to engineering journals, and his comments regarding them are so good they are quoted here verbatim: "The great value of the purchase and perusal of the technical periodicals and other than the required textbooks lies in beginning a library and in establishing habits of independent thought and study while still in position to obtain friendly aid and advice from the faculty. The files of the technical periodicals form a very important part of every engineer's library. Even the six or eight volumes of any good engineering paper which the student should accumulate afford many descriptions and illustrations of engineering works and of the methods of designing and constructing them. But back numbers are difficult to obtain; and if the graduate does not have them he is not likely to buy them and consequently will miss their aid in solving his first practical problems. Without them his knowledge of what has been done in the engineering world will not extend much back of the day he began work in his first position." The importance of technical papers as a source of information and a record of current events is widely recognized, but it is not so generally appreciated that they are practically invaluable in connection with studies conducted after graduation. This is not said as a matter of self-praise, but rather as a repetition of an opinion many times expressed by engineers who have found the technical press invaluable to them in their early days of actual work, when they could no longer turn to their college instructors for advice and help.

The Passaic River Pollution Awards.

Vice-Chancellor Stevens of the New Jersey Court of Chancery made an award to riparian property owners a few months ago for the pollution of the Passaic River, which is unique in its nature and consequently deserves attention as an important precedent. The New Jersey courts have had the case (*Doremus et al. v. Mayor, etc., of City of Patterson, N. J., et al.*), before them in one form or another for some years, and as the recent award apparently settles the controversy the facts as well as the judicial conclusions may be recited at some length. There were about twenty of the properties in the suit, generally strips of land 150 to 600 ft. wide, running back from the river over a mile in some cases. Most of the land is used for farming or truck gardening. The houses are old and without modern improvements, and the means of access to the district are not such as to attract suburban residents to it. Acting under a legislative act, the city of Paterson constructed sewers with their outlets in the river and proceeded to discharge sewage into the stream, something that the courts of several States have definitely held to be strictly legal. In this case, as in others concerning stream pollution, the courts have ruled that it was not until Paterson poured more sewage into the stream than it could dilute to an inoffensive condition that the property owners could be said to have been injured. As soon as it became evident that they had a reasonable ground of complaint they applied to the Paterson Board of Health to abate the nuisance. Their request was unsuccessful and they then applied to the State Board of Health; that body could render no aid, so they applied to the Legislature, only to fail again to secure relief. Accordingly, they were forced to bring a suit for an injunction against the city to restrain it from polluting the river and interfering with their en-

joyment of their rights as riparian owners. The Court ruled that an injunction preventing the use of the sewers would work great injury to the city and ordered the property owners to accept compensation for the damages to their lands, the amounts to be settled by a court of equity. The property owners accordingly brought an action for damages "calculated upon the basis of said injuries being permanent," and in the course of time the city agreed, in substance, that it would cease polluting the river in the manner complained about within five years of the date of its answer. It therefore devolved upon the Court to determine the amount of damages incurred by the owners of the property, a problem in equity of a most complicated character.

In order to have a basis on which to build up the awards, it was necessary to determine when the damages began, and the Court took a great mass of testimony on this subject. Part of it was expert testimony concerning the amount of sewage that can be discharged into a stream without causing a nuisance, but this apparently did not have much influence on the decision of the Court. The date was fixed at 1892, from the testimony of the property owners, which indicated that it was not until then that the condition of the river had any appreciable influence on the use of the stream for fishing or bathing. By that time, however, evidences of sewage pollution were marked. Some attempts were made to fix an earlier date, on the ground that when sewage was first discharged into the stream by the city those using the water were in danger of typhoid fever, but this contention was not sustained, because such danger occurred when the first householder on the stream above the district built an outhouse draining into the stream. This method of determining the date of the beginning of a nuisance of this nature deserves particular attention, because in this case the facts were determined by a judge and not by a jury and indicate the point of view of a trained judicial mind approaching a subject of an engineering nature.

While it was difficult enough to fix the date for beginning the computation of damages, the estimation of their amount was far more complicated, although it was somewhat aided by an agreement between the parties that the money equivalent for the injunction was to be compensation for the diminution in values of the lands and property rights alone. There was no question about the constant increase of the nuisance, for the population of the city had increased from 105,000 in 1900 to 110,000 in 1905, the number of factories and the quantity of industrial sewage was steadily increasing, there was a gradual increase in the offensive sludge in the river, and the quantity of water flowing in the river was being steadily reduced by the diversion of water from the upper part of the catchment basin for the purpose of supplying towns and cities. The city did not deny that it was under legal obligation to make some compensation, but it sought to minimize the amount. Its first contention was that it was not responsible for contamination due to street wash, but the Court sustained this contention only in part, holding that, while the city was not responsible for the street refuse washed directly into the river, it was to be charged with the refuse swept into the river through the sewers. The second contention was that the city ought not to give compensation for the whole injury inflicted, but should be allowed to deduct from that amount a sum representing the injury that would have been inflicted by a city the size of Paterson without sewers. This contention was not sustained by the Court. A third contention was the equitable apportionment of the damages between the city as a whole and the industrial establishments. The Court reviews the testimony on the subject at considerable length, but does not anywhere state its conclusions, although apparently of

the belief that the city is responsible for about three times as much pollution as the factories.

The final decision was reached by first fixing the annual rental value of each piece of property within what may be called the zone of influence of the river. These values were estimated by the Court by weighing the testimony concerning them and then making whatever allowances seemed necessary, on account of the condition of the buildings, their location with respect to the river and to the electric railway and other factors. The Court then decided that the pollution due to the city sewage and the proportion of the street refuse swept away through the sewers was 5 per cent. of the annual rental value of the property in 1892 and increased 1 per cent. annually thereafter. The Court states that this award is necessarily an approximation, which is self-evident from the nature of the case. Its importance lies in the fact that it is an attempt to reach by logical methods a fair judgment in a complicated controversy, where no single factor can be definitely fixed and the relative accuracy of the estimates of the different factors introduces additional complication. The decision is one which shows long study on the part of the judge, in order to determine the weight of the expert testimony and to fix upon a sound basis for the awards, and, while an engineer might modify some of the details, the fairness of the process, as a whole, is manifest. It establishes a precedent concerning appraisals of an engineering nature, and engineers who wish to make criticisms of the method are invited to send them to this journal, since a thorough discussion of the matter now will be particularly timely.

Conservation of Natural Resources.

The conference last week at Washington of the governors of the various States, held at the invitation of President Roosevelt to discuss the conservation of the natural resources of the nation, produced such a remarkable unanimity of opinion favorable to the prevention of further waste and extravagance as to mark apparently a new epoch in the development of the industries of this country. Forty-one of the governors attended the conference and the remainder sent personal representatives. In addition, three officials and citizens of the different commonwealths and the executives of all the representative national trade and technical organizations were also invited to attend and to assist in the discussions. The sessions of the conference were held in the East Room of the White House, where no similar meeting had occurred before; the President opened each of the sessions, after which he called a governor to the chair, except for the last session, throughout which he presided as chairman. The meeting was therefore extraordinary in every sense, even though the body had no executive or legislative powers, and it has doubtless inaugurated a movement that will produce results of eminent importance to the future industrial development of the nation.

The reason some such similar action has not been taken before appears to be beyond explanation. The great stores of natural wealth in this country were so long considered illimitable, that any discussion of the conservation of these resources was held as academic, or at best scientific speculation. But the necessity of preventing a continuation of the prodigal methods practiced in this country in various industries depending on natural resources has been recognized for years by a class of far-seeing men, and recently, as the result of these methods have become more evident, by a rapidly growing number. The potentiality in the development of other resources has been less understood generally, although appreciated somewhat by certain interests having to do with such development. The general Government has done much, especially in recent years, toward

the preservation of what remains of the various resources that have been depleted in particular, and in an attempt to prevent similar exhaustion of other resources. Some of the individual States have also undertaken work more or less along the same lines, but the results of this independent endeavor have naturally been purely local. Conditions have become so momentous meanwhile that some immediate action is imperatively necessary. In most instances this action can be directed best by the Federal Government, since a majority of the questions to be considered either involve several States or are primarily of national concern and must be treated in a manner that will promote the welfare of the entire country.

The frightful manner in which some of the natural resources have been wasted in the past that is now well recognized, cannot fairly and properly be attributed in general to greed. As an example, the cutting of forests has probably been more extravagantly carried on than any other industry dealing directly with natural wealth. When this country was peopled along the Atlantic Coast by whites it was necessary to clear great areas of forests for farms and settlements. As a consequence, the early inhabitants of the eastern edge of the country came to look on timber as an obstacle and not until a comparatively few years ago was recognition had of the danger of continuing the reckless method of lumbering still in vogue that in a large measure owes its origin to this cause. The harvest of lumber from our apparently boundless virgin forests with such unparalleled short sightedness has indeed been partly required to obtain a product that could be sold in competition, since consumers would have only the best. The same condition exists to a large degree in coal mining and other industries dependent on exhaustible resources. A remedy for the appalling waste of the past must therefore in most instances start with the consumers; and there must be also a profitable market for the enormous percentage of the nation's natural wealth that is being wasted so excessively.

The conference did not form a permanent organization, nor was any such organization considered in advance of the meeting, but from opinions expressed by the executive officers of the States the governors may come together again to advance the movement already inaugurated. Moreover, several of the governors said they would endeavor to institute in their respective States reforms and investigations designated to change existing conditions pending towards the exhaustion of resources. These efforts will certainly affect beneficially the people of the States concerned, and at the same time relieve the general government to a large extent. The conference achieved the issue for which it was called, however, by bringing the necessity of proper technical treatment of our natural resources forcibly to the attention of the entire country in such a way that immediate advantages are certain to result and benefits of continuously increasing value to the future of the nation will be achieved. The engineering profession must necessarily play an important part in this great work, and its members' interest must be active to the extent, if necessary, of personal sacrifice in the discharge of their obligations as citizens.

Notes and Comments.

THE BLACKWELL'S ISLAND BRIDGE over the East River in New York City has been alleged by the local press to embody imperfections due to changes from the original designs, which charges are apparently without actual cause in so far as the structure itself is concerned. As has been stated by these reports, it is true that the allowed unit stress in the bottom chords of this bridge are greater than those under which failure occurred in the Quebec bridge, but the fact that two col-

umns or struts fabricated from identically the same material may have widely varying safe carrying capacities, depending on their design, is fundamental. Be that as it may, the erection of the great span has been substantially completed and the enormously increased temporary stresses due to the 625-ton traveler at the extremity of the cantilever arm, involving a tremendous moment which can never be repeated after the completion of the bridge have been borne without the slightest injury to the structure. The connections between the cantilever arms have also been made successfully, and the deflections of the bridge are as calculated. Furthermore, there are no evidences of weakness or distress in any of the members, although the latter are now subject to a large portion of the stresses due to dead load. These conditions are believed to be sufficient assurance for the safety and integrity of the structure, so that the tests of large-size members, such as have been suggested, are scarcely needed, although these tests would produce much valuable data that might be used in designing other structures. Thus far no evidence has been shown, however, that would cause any apprehension as to the safety of this structure.

MUNICIPAL WORKS IN SAN FRANCISCO of a much-needed character can now apparently be undertaken in a comprehensive manner, since the issuance of \$18,200,000 in bonds has been approved by popular vote as required by law. The total debt of the city, including the bond issue just voted, will be less than one-third the amount allowable under the city's charter limitation. The ratification of the issue of these additional bonds means much to the city at this time. Funds will now be available for an independent high-pressure fire-protection system, that is estimated to cost \$5,200,000. The plans for this system, which have been prepared for some months, include suggestions of the engineers of the National Board of Fire Underwriters and are reported to have been commended by those engineers. The high insurance rates that have prevailed in San Francisco since the disaster in April, 1906, are therefore expected to be reduced by the completion of this independent system of high-pressure mains. About \$4,000,000 of the new fund is to be used in constructing additions to the sewerage system, as the latter has long been inadequate to give satisfactory service and was damaged badly in some sections of the city by the earthquake. The plans for these additions, the preparation of which was started about sixteen years ago, have been very fully developed. The greater portion of the area occupied by the city permits of gravity drainage. Several outfall sewers extending into San Francisco Bay are calculated to discharge into strong tidal currents, thus expecting to prevent perceptible pollution of the waters of the bay. A fund of \$1,000,000 for a garbage-disposal plant or plants is also to be provided out of the bond issue. As was explained somewhat at length in this journal recently, the collection of garbage in San Francisco has been in the hands of private scavengers and until lately has not been satisfactory. The garbage has also been disposed of in a private incinerator at a fixed price per ton to the scavengers. It therefore appears that the city proposes to at least provide for the disposal of a part of the garbage, and municipal collection of the latter has also been advocated. The recovery of San Francisco from the disaster which destroyed the business district and a large portion of the remainder of the city has been remarkable in every way. The permanence of this recovery and the future welfare of the city depend so greatly on the improvements provided for by the proposed bond issue that the result of this recent election is of specially great moment to the entire community around San Francisco Bay.

DIFFICULT SUB-SURFACE BUILDING WORK IN CHICAGO.

Work is in progress on a nine-story reinforced-concrete warehouse building, 80 x 180 ft. in plan, for the Steele-Wedeles Co. on the north bank of the Chicago River, immediately west of the Dearborn St. bridge crossing. A terminal station for the Chicago Subway freight-tunnel system, having four stories below the ground level, is also being built under this warehouse at the same time. The warehouse building and the terminal station will, however, be entirely distinct, although the columns for the building over that part of the site also occupied by the sub-surface terminal station will be carried down to spread footings of reinforced-concrete under the fourth sub-basement floor of the latter. The remainder of the columns of the building and the side and end walls of the underground terminal station will be carried by circular concrete columns, varying from 4 to 5.5 ft. in diameter and extending to a total depth of about 65 ft. below Chicago datum, which is approximately the mean level of the water in the river adjacent to the site.

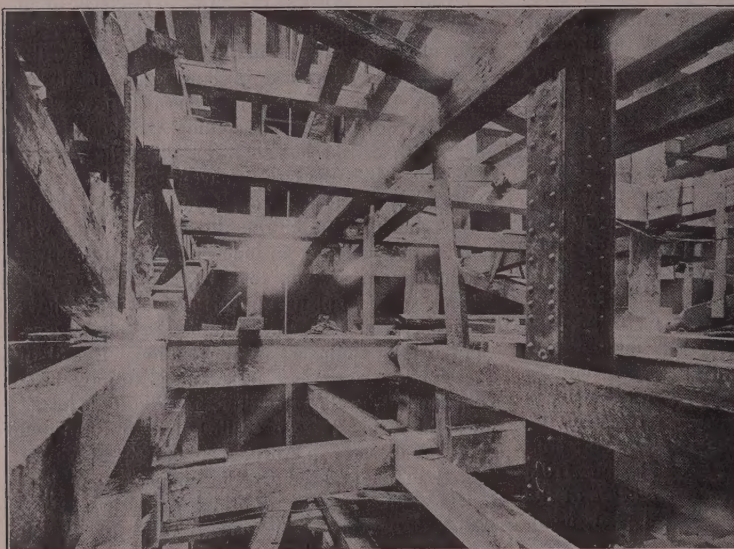
The terminal station is designed to provide for receiving, storing and distributing the various

against the end of an existing eleven-story fire-proof brick warehouse building, having thick heavy walls with a comparatively small amount of steel in them. The other side is flush against a steel viaduct approach to the northern end of the Dearborn St. bridge over the river; in fact, teaming entrances to the second floor of the building will be made directly from this viaduct. One side wall of the subway terminal station structure is directly under the proposed warehouse building wall adjacent to the viaduct approach to the bridge, and one end of the structure is approximately 30 ft. from the wharf line along the river.

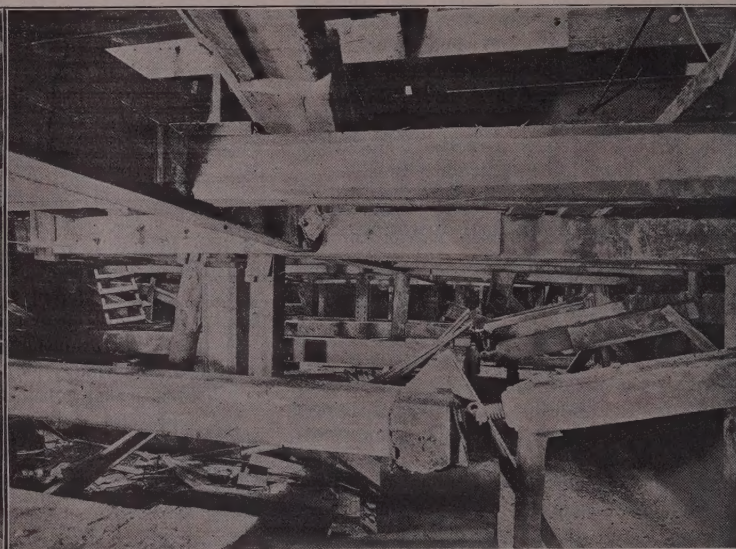
The underground structure will be 38 ft. x 131 ft. 2 in. in plan, and will have a total depth of 44 ft. from the ceiling of the first sub-basement to the bottom of the fourth sub-basement. The floor and side and end walls of the structure will be of reinforced-concrete, designed to resist the unusual great pressures that will be brought to bear on them due to the great depth reached in the heavily-loaded soft blue clay, which covers bed rock to a depth of 100 to 110 ft. at the site. The bottom floor has a uniform thickness of 2

below the surface. Occasional pockets of softer materials and sand are frequently encountered in this clay, and usually a stratum of quicksand and boulders occurs directly over the rock. While the clay is comparatively stable when confined, it flows readily over long distances when excavations are opened in it adjacent to heavy structures. On this account, practically all of the more recently constructed buildings in the business district have circular concrete footings carried down to the hardpan, or to rock. As the exceptionally heavy existing adjacent warehouse building is on pile foundations, and the bents of the viaduct are carried by concrete piers on piles, it was absolutely essential to maintain the ground in its original position while the deep excavation over the comparatively large area was open. The close proximity of the river at one end and of the important railroad switch-yards at the other end of the site also required special care to be exercised in the execution of the work.

Before any excavation was made, a wall of steel sheet piling was driven entirely around the site of the terminal station structure. This sheeting was of the I-beam type with special steel clips patented by Mr. M. W. Cluxton. The piling consisted of 9-in. and 12-in. I-beams in 45-



Interior of Excavation, Showing Character of Timber Shoring.



Load on the Lower Waling Transferred to Blocking Timber.

classes of freight handled in the subway. Five main trunk lines of the latter will enter the station at the level of the fourth sub-basement floor and will connect with a series of switch-tracks laid in the floor. Two elevator shafts, both oval in plan, with 8-ft. 8-in. x 14.5-ft. axes, will extend from the level of these switch tracks to the three floors of the station above. The tunnel cars will be raised to these upper floors in cages operated in these shafts, tracks being laid on the various floors to permit the cars to be shunted along the latter. The proximity of the station to the central business district of the city, and particularly to a large number of wholesale merchandising establishments and warehouses will thus render it an important part of the great subway freight tunnel system which now extends under practically the entire business section of the city.

The soil conditions at the site, together with the difficulties presented by the surroundings, render the construction of the deep underground station one of particular hazard. One end of the site of the nine-story warehouse building abuts on the wharf line of the river, the latter having a minimum depth of approximately 22 ft. at this point. The opposite end is parallel to a number of switch-tracks of the Chicago & Northwestern R. R., that carry a large volume of important traffic at practically every hour of the night and day. One side of this building will be erected

ft., and is reinforced with two layers of heavy steel rods, distributed so as to give it sufficient strength to resist the upward pressure caused by the loads on the soil surrounding the site. The end and side walls are uniformly 2 ft. 6 in. thick and are reinforced with a vertical row of 1½-in. round steel rods. The reinforcement of the bottom floor is carried up into the side walls, and the rods in the latter extend into that floor, thus making a monolithic concrete structure. The three intermediate floors between the bottom floor and the floor of the basement of the warehouse building over the station are of concrete, with a uniform thickness of 1 ft. 7 in. and are thoroughly reinforced with structural shapes, the latter having their ends embedded in the walls. These floors are also braced apart on the longitudinal center line of the structure by steel columns, spaced 16 ft. 1 in. apart on centers, which columns carry the sub-basement floors and the columns of the main building.

The ground level at the site, when operations were started, was from 2.5 ft. to 4 ft. above the normal level of the water in the river. The clay overlying the bed-rock at the site varies greatly in character from this original ground level down to the rock, but is generally the same as that encountered in the entire central business section of the city. The upper strata are comparatively soft blue clay, which increases in stiffness with the depth until hardpan is reached 60 ft. to 90 ft.

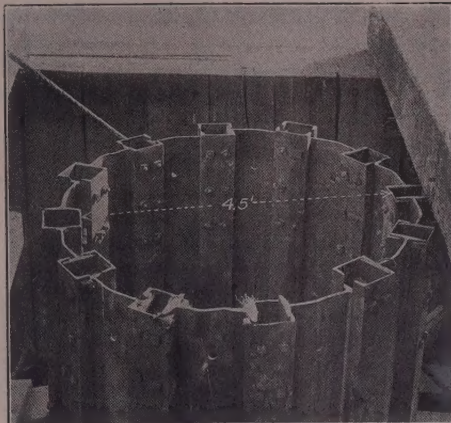
ft. lengths. The driving was done in about two weeks, with no difficulty, by means of a pile driver having a No. 2 steam hammer. After the sheeting had been driven, round wooden piles, 46 ft. long, were driven down about flush with the ground surface in the rectangular space enclosed by the sheeting to form the posts of a framework of heavy timber bracing necessary to support the sides and ends of the latter against the heavy pressures brought on it as the excavation was made. These pile posts were driven in three regular longitudinal rows, the spacing of the rows being 13 ft. on centers transversely and the piles in the rows 20 ft. on centers longitudinally.

Before the excavation was started chutes were carried down through the space enclosed by the sheeting to a line of the subway which had previously been built under the site of the station. The materials removed from the excavation were wheeled to the mouths of these chutes, through which they were dropped into cars in the subway below. When the excavation had reached a depth of about 5 ft., an 18 x 18-in. waling timber was placed horizontally against the wall of steel sheeting entirely around the excavation. A horizontal course of longitudinal and transverse braces of heavy timber was erected between the walings on the ends and sides of the excavation, with the round timber piles previously driven as intermediate posts. This horizontal course of bracing reacted against the steel sheeting along both sides

and both ends of the excavation. The excavation was then carried down uniformly over the whole space enclosed to the next 5-ft. level, where a second horizontal course of waling and timber bracing was placed. In this manner the excavation was continued until it finally reached a level about 6 in. below the lower ends of the steel sheet piling, with a total depth of 44.5 ft. below the level of the water in the river. This deep excavation over the long, wide site of the station structure then contained a crib of eight horizontal courses of heavy timber bracing, with the previously-driven round timber piles as intermediate posts in this crib, and with vertical spacers between the walings of the courses at different points as required. Diagonal timbers carrying jack-screws were also placed between the timbers in the adjacent horizontal courses to give the crib additional lateral stability.

When the excavation had been carried down to within about 2 ft. of the bottom of the floor of the station structure, caissons were started for the circular concrete footings which carry the side and end walls. These footings are 16 ft. 1 in. apart on centers under the side walls of the structure and three footings are placed under each end of the structure, one of these

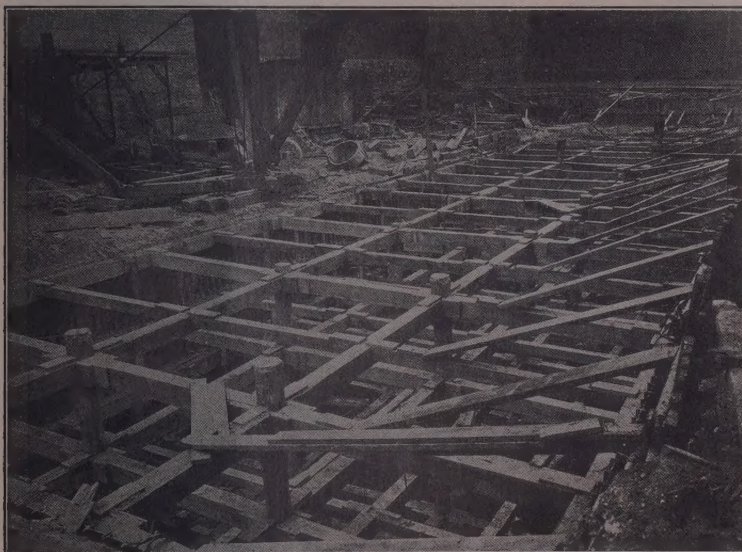
bracing. After the load had been thus transferred, the walings of the second course from the bottom were removed and the ends of the horizontal braces against them were sawed off about 2 in. inside the inner edge of the wall forms. The uprights of the latter were next carried up to the third course of timbers, with their tops



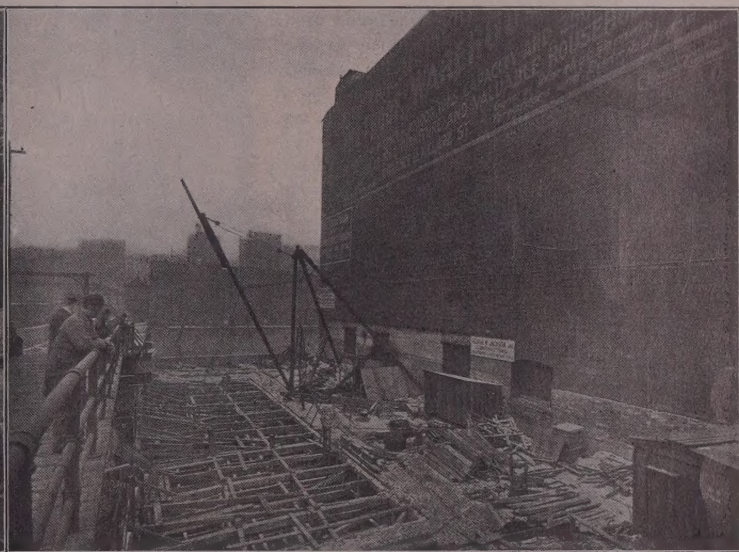
Sheeted Caisson back of River Bulkhead.

the steel beams of the floors had to be placed as the walls were built, thus involving a considerable difficulty in the transference of load from the bracing adjacent to them. The courses of bracing and the spacing of the timbers in each course had, however, been arranged in advance to miss the steel work, but the unavoidable deflection of the vertical round timber piles driven previous to the start of the excavation, and the necessity of providing additional lateral braces greatly complicated the erection of the steel.

The steel sheeting was found, when the excavation was made, to have a remarkably straight and uniform alignment, with very few instances where members had been deflected. This condition is specially remarkable in light of the fact that the units used were of such great length and comparatively small size. Practically no difficulty was experienced from the soft blue clay flowing through the joints between the sections of the piling while the excavation was in progress, or during the time the bottom concrete floor and walls were being built. The piling was also held in almost perfect alignment during that time by the system of braces used. No settlement was apparent in the adjacent heavy warehouse or in the ground around the site. This result is par-



Close View when Excavation was about Half Completed.



General View of Excavation for Subway Terminal Station.

three being at each corner and one at the middle of the end wall. These caissons were sheeted with short vertical wooden lagging held in place by horizontal steel rings and were handled in the usual manner followed in providing foundations for large buildings in Chicago. As soon as the footings in one end were finished, the main excavation at that end was completed down to the bottom of the lowest floor of the building. Work was then started on the concrete floor, which was carried forward simultaneously with the work on the remainder of the footings and the completion of the main excavation. The lower ends of the walls of sheet piling were thus exposed for the shortest possible length of time and were then thoroughly braced in place by the heavy floor.

The completion of the concrete floor at the bottom of the structure permitted the removal of the walings of the lowest course of bracing, so forms for the concrete walls could be erected up to the level of the next course of bracing above and the concrete walls built up to that level. After this concrete had set sufficiently a horizontal blocking timber was nailed to the uprights of the wall-forms, directly under the ends of the transverse braces against the walings of the second course from the bottom. The load on the walings of this course was then transferred to the lower course of timbers by means of jack-screws in drums placed at a vertical angle between blocking timbers and the timbers of the lower course of

braced against a horizontal 3 x 6-in. plank laid parallel with the wall along the top of these third course timbers. The concrete wall could thus be completed to the third course of bracing without interference with the latter. Then, when the concrete had set the inclined drums between the first and second courses of bracing could be removed, with the result that the ends of the transverse timbers of the second course that had been cut off inside the forms were again loaded by reacting against the finished concrete. The load on the walings of the third course of timbers could therefore be transferred to the second course of bracing by inclined drums placed against blocking timbers attached to the uprights of the concrete forms, directly under these third course timbers.

Following this sequence of operations it was possible to build the walls without any intermediate courses of bracing between those originally placed, and with a minimum portion of the wall of steel sheeting left unsupported at any time. The concrete was carried up between two courses of bracing entirely around the structure before the loads were transferred from the timbers in the course above. All of the bracing work was cut and the new bracing placed during the day to avoid every possibility of accident. The remainder of the operations were handled by three 8-hr. shifts.

The steel columns of the station structure and

ticularly significant when the difficulties which have been experienced heretofore in almost every deep excavation that has been made under similar conditions in Chicago are considered.

Along the side of the excavation under the edge of the viaduct approach to the Dearborn St. bridge the steel piling had to be omitted at four points for a distance of from 4 to 7 ft., on account of the interference presented to the pile driver by cantilever beams in the floor of the viaduct. As the excavation was made these spaces were sheeted with pieces of heavy plank placed horizontally, with their ends back of the steel sheeting. It was possible to handle these patches in the latter in such manner that no difficulty has been experienced in maintaining the viaduct in service, although the breaks in the wall of steel sheeting came directly opposite the bents of the viaduct.

The concrete was made in a mixer set up under the edge of the viaduct at a level 10 ft. above the top course of bracing. Runways were laid on the latter to various parts of the work, with chutes leading down at convenient intervals into the bottom of the excavation, or directly into the wall forms. The concrete was handled in wheelbarrows from the mixer to these chutes, through which it was dumped directly into place, or to shoveling platforms below. Notwithstanding the fact that the work of transferring the load on the walings against the walls of sheet piling was

so complicated, a rate as high as 10 cu. yd. of concrete an hour was maintained for six hours during the time the wall construction was in progress, and the progress has at all times been rapid.

At the time these notes were prepared, the walls were about half way to their full height. It was intended at that time to continue them to the level of the floor of the basement under the warehouse building over the station structure before starting the construction of the intermediate floors. After these three floors are built, starting at the bottom, and as soon as the concrete in them has set sufficiently, the courses of timber bracing were to be removed so that finally the loads on the walls of the structure will all be distributed by the various floors. The removal of the large amount of timber used as bracing can readily be accomplished by dropping it to the lowest basement level where it can be loaded on flat cars and delivered to the storage yards of the contractor.

Each column of the frame of the warehouse building is also to rest on a circular concrete footing carried down to about the same depth as the footings under the walls of the station structure. Work on these footings had just been started at the time these notes were prepared, and Jackson interlocking steel sheeting was being used to line the excavations for those close to the river. The remainder will be sheeted with wooden lagging and iron rings in the usual manner.

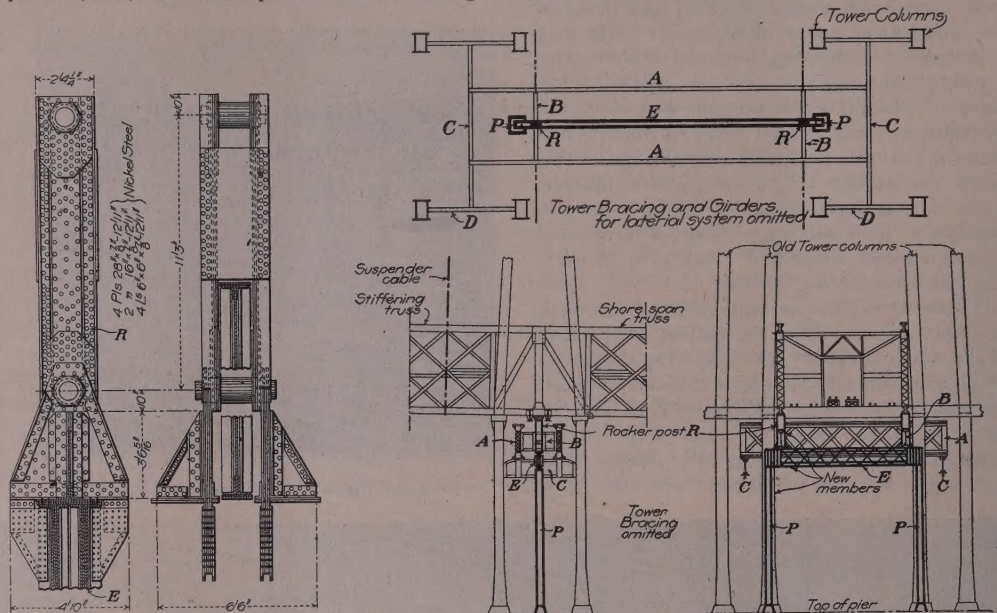
An elevator shaft connecting the basement of

original condition by the long steel sheeting that no cracks or apparent settlement have occurred in the heavy walls of the building.

The tunnel station building and the foundations for the reinforced concrete warehouse are being constructed under contract by George W. Jackson, Inc., under the supervision of Mr. George

Williamsburg Bridge Towers.

The double decks of the 1,600-ft. suspended span of the Williamsburg Bridge are carried by a pair of quadruple intersection riveted stiffening trusses 40 ft. deep near the towers and 67 ft. apart on centers, which are continuous from cen-



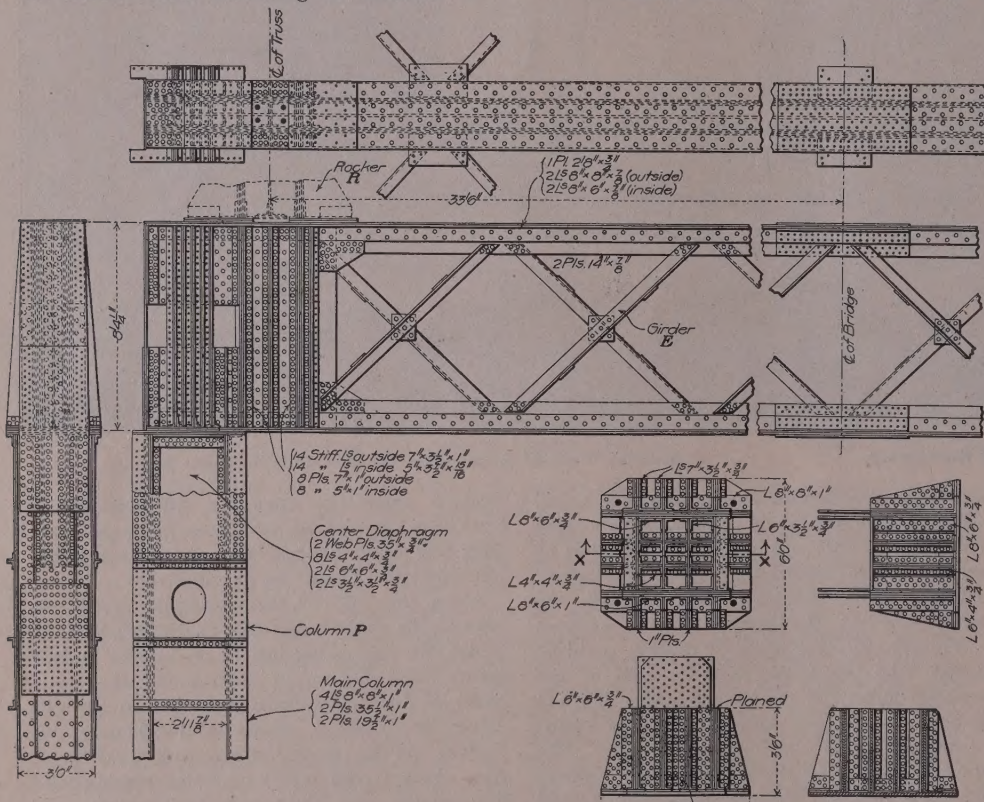
Rocker Post.

Base of Tower; New Construction Shown by Heavy Lines.

ter to center of the main towers of the structure; and 23 ft. 6 in. deep beyond these points at each end where they support the extremities of connecting spans, 217½ ft. long, carried at their opposite ends on the 59-ft. cantilever projections of similar spans, seated at their river ends on small steel towers about 300 ft. from the main tower. This arrangement, while it secures single supports at the main towers for the suspended and approach spans, involves rather complicated stresses and requires an elaborate system of auxiliary girders, trusses and columns to transfer the span loads to the main tower and distribute them equally among its eight columns. In order to provide for the longitudinal motion due to temperature variation, each main truss is supported on the transverse center line of the tower by a vertical rocker post 11¼ ft. long, marked R in the accompanying diagram, which indicates by heavy full lines the original system of girders and trusses supporting the spans from the main towers, as illustrated in The Engineering Record of Feb. 12 and 19, 1898, and May 4, 1901, but omits other members at this point.

The original rocker posts were adequate for the service for which the bridge was designed and for any loads which are likely to come upon them at present, but in order to make the tower support correspond to the remainder of the structure in the development of its full capacity, and to permit the future operation of ten-car trains it was found desirable to increase the strength of the rocker posts and reinforce their support. Contracts have therefore been awarded for four new rocker posts substantially like the existing ones, except that they are made of nickel steel instead of carbon steel; and for additional girders and columns to carry that portion of their maximum load which may be in excess of the strength of the girder system originally provided for distributing it among the columns of the main towers.

The new rocker posts P will have the same bearings as the old ones in the stiffening trusses and in the short longitudinal plate girders, B supported by the transverse trusses A A that transmit the load to the longitudinal plate girders C C on the center lines of the towers and through them to the transverse plate girders D D, con-



Girder and Column Supporting Rocker Posts.

PEDESTAL FOR NEW COLUMN P

the warehouse with the tunnels of the subway system has been built at the inshore corner of the site close to the existing adjacent eleven-story warehouse building. The finished cross-section of this shaft is an oval, with 8-ft. 8-in. by 14.5-ft. axes. The shaft is lined with massive concrete and was built in an excavation 24 x 24 ft. in plan, the sides of which were held in place by the special type of I-beam steel sheeting in 45-ft. lengths. This excavation was cross-braced with heavy timbers while it was open, and until the concrete lining of the shaft was finished. Notwithstanding the close proximity of the tall, heavy building adjacent to it and the soft, plastic nature of the clay in which it was made, the surrounding ground was so completely maintained in its

W. Jackson, president and chief engineer of that organization. Mr. Tom Matson is foreman in immediate charge.

A STEAM TURBINE TEST under commercial conditions was reported by Mr. M. H. Merrill at the recent convention of the National Association of Cotton Manufacturers. The unit, a 500-kw. Westinghouse-Parsons turbine in cotton-mill service, was run with a load of 313 kw., with steam at 170 lb. and a vacuum of 27.5 in. The condensed steam was measured by meter and checked by weighing, and in a run of 11½ hours it was found that the consumption of steam, including that supplied to all auxiliaries, was 24.56 lb. per kilowatt-hour.

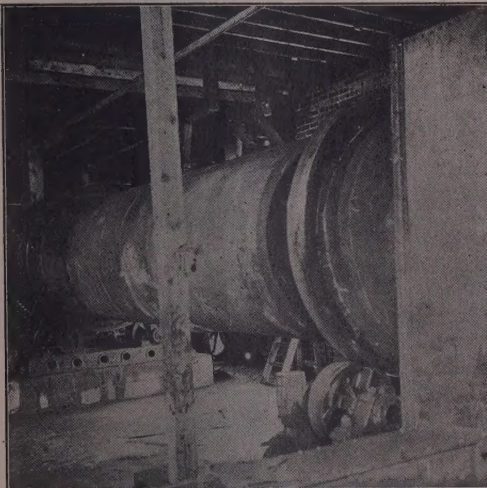
nected to the column posts. The increased loads on girders *B B* are controlled so as not to increase the load on any of the other girders by auxiliary supports given to the lower pin of the rocker by means of pedestals resting on a new girder *E* in each tower which is supported on two new columns *P P* and has top flange bearing on the lower flanges of girders *B B* adjusted to take the required proportion of load from the latter.

The original rocker posts were of carbon steel with a cross-sectional area of 165 sq. in. The new posts have the same cross-sectional area and are proportioned for maximum loads of 3,500,000 lb. each. They are made of nickel steel, which contains not less than 3.25 per cent. of pure nickel. The plates and angles are required to have ultimate strength and yield point of 99,000 lb. and 55,000 lb. minimum per square inch respectively, and the rivet steel to have corresponding values of 75,000 lb. and 45,000 lb., respectively. Both of them showing an elongation of 1,600,000 divided by the ultimate strength. Cold specimens are required to bend 180 deg. flat and to endure being opened flat by a hammer. A variation of 5,000 lb. per square inch in either direction from

by exterior and interior web-stiffener angles. The spaces between the diaphragms are grouted to protect the metal against corrosion.

Girders *E E* are supported on columns about 75 ft. long with rectangular cross sections made with pairs of built channels latticed. Each channel in the column is made with one $35\frac{1}{2} \times 1$ -in. and one $19\frac{1}{2} \times 1$ -in. web plate and two $8 \times 8 \times 1$ -in. flange angles. The columns are in the longitudinal planes of the main tower columns, and are designed to clear the vertical diagonal bracing of the latter which passes between their webs and is field-riveted to them, thus providing for a distribution of the 700,000 lb. maximum uplift from each stiffening truss to the main tower and obviating any anchorage. This arrangement necessitates the shipment of the column before its members are assembled together and their separate erection on opposite sides of the latter.

The new construction is so connected to the old that after erection it will apparently form a part of the original design and will not be conspicuous as an addition or modification of the old tower. The column bases, 6 ft. square, are riveted pedestals integral with the body of the column and the heavy bottom plates are rein-



New Rotary Dryer and Steel-Body Dump Wagon; Cleveland Garbage Works.

the specified strength will be permitted. Steel with pitted or heavily scaled surfaces is not accepted and all steel $\frac{3}{8}$ in. or more in thickness is either drilled from the solid or sub-punched and reamed for rivet holes. Great care is taken to avoid burning rivets and all of those which "spit" when taken from the furnace are rejected.

The pin holes in the new rocker posts are of the same diameter as in the old rocker posts and the upper ones engage the same connections in the stiffening trusses. The lower pins pass through the original bushings on the webs of the girder *D D* and projecting beyond them engage bearings on the new girders *E E*. As the pins are parallel to the webs of girders *E* and over 4 ft. above their top flanges, special bearings are provided for them by riveting to the vertical web-stiffeners of the girders transverse plates which project above the top flanges and are braced and stiffened longitudinally as indicated by the detail section and elevation.

The girders *E* are of special construction, each of them consisting virtually of a pair of twin lattice girders built with heavy angles and connected together with $28 \times \frac{3}{4}$ -in. top and bottom cover plates, common to the flanges of both girders. They are about 76 ft. long and $8\frac{1}{2}$ ft. deep over all and are riveted up complete in the shop, except for top and bottom flange splices at the center point which are field riveted. The rocker posts are only $3\frac{3}{4}$ ft. eccentric from the supporting column, the heavy shear at this point being provided for by solid web plates about 9 ft. long at the ends of the girders, which are heavily reinforced by vertical transverse diaphragms and

forced by numerous longitudinal and transverse vertical web plates or gussets and by 6×6 -in. vertical angles, which stiffen the base plates and distribute the load over cut granite pedestals seated on the pier coping.

The new work is being executed by the Department of Bridges of New York City, Mr. C. M. Ingersoll, Jr., chief engineer; Mr. J. W. Stevenson, commissioner, and Mr. Leon S. Moisseiff, engineer in charge of computations and details. The new work includes about 294 tons of structural steel and 45 tons of nickel steel, the contract for which has been awarded to the J. H. Gray Co., New York, for a contract price of \$39,230 and this steel will be fabricated at the Cambria shops.

TRAIN DISPATCHING BY TELEPHONE has been inaugurated recently on a number of trunk-line steam railroads, including the Chicago, Burlington & Quincy, the Chicago, Milwaukee & St. Paul, the Illinois Central, the Chicago, St. Paul, Minneapolis & Omaha and at a number of points on the New York Central lines. In most of the cases the use of the telephone is at detached intervals on the systems and auxiliary to the telegraph, but, due to the satisfactory results obtained, its use is being rapidly extended. It is the general practice for the train dispatcher to copy the order in the order book as he gives it instead of making a copy when the message is repeated back to him, as is usual with the telegraphic system. The speed of the message is thus kept within the range of the receiver by the ability of the dispatcher to write.

The Cleveland, Ohio, Garbage Reduction Works.

The city of Cleveland has a municipally owned and operated garbage-reduction works from which quite remarkable results in the cost and satisfaction of operation are being obtained. Prior to 1905 the garbage produced in Cleveland was collected and reduced under private contract at a cost to the city of \$69,400 a year. On Jan. 1, 1905, the city purchased from the contractor for \$87,500 the reduction works and collection equipment. At that time the works had a capacity of about 110 tons per day; since then these works have been practically rebuilt and their capacity increased to 240 tons per day. While an endeavor has been made to operate the garbage collection and disposal department with as much economy as possible, it has been considered that the work of collection of garbage is of such importance, and has so large a bearing on the health of the community that a special effort is put forth to give an improved service. An outline of the process employed and of the apparatus used in the reduction of the garbage was presented in a paper read recently before the Civil

TABLE 1.—COMPARISON OF AMOUNT OF GARBAGE DELIVERED AT REDUCTION PLANT
During the Years 1905 and 1906.

Month.	1905.	1906.	Increase.
January	4,784,000	3,752,000	1,032,000
February	3,994,000	3,316,000	678,000
March	4,520,000	4,070,000	450,000
April	4,694,000	4,218,000	476,000
May	5,430,000	5,018,000	412,000
June	5,936,000	5,808,000	128,000
July	5,464,000	5,592,000	*128,000
August	8,024,000	6,360,000	1,664,000
September	7,478,000	6,906,000	572,000
October	7,098,000	5,996,000	1,102,000
November	6,204,000	4,736,000	1,468,000
December	6,156,000	4,992,000	1,164,000
Total	69,782,000	60,764,000	9,018,000
Average per month.....	5,815,167	5,063,667	751,500

*Deducted account July decrease.

During first six months of 1906 and 1907.

Month.	1907.	1906.	Increase.
January	6,402,000	4,784,000	1,618,000
February	5,512,000	3,994,000	1,518,000
March	6,067,000	4,520,000	1,547,000
April	6,144,500	4,694,000	1,450,500
May	6,139,000	5,430,000	799,000
June	5,719,000	5,936,000	*217,000
Total	35,283,500	29,958,000	6,623,500
Average per month.....	3,997,250	4,893,000	1,104,250

*Decrease.

Engineers' Club of Cleveland by Mr. W. G. Springborn, director of the board of public service of Cleveland. From this paper and from additional data supplied by Mr. Springborn, the following notes have been prepared.

The loading station and the stable are located on Canal Road, adjacent to Central Viaduct, which is about three-fourths of a mile from the center of the city. Here the garbage is delivered in wagons and loaded upon cars ready for shipment to the plant, which is located at Willow, Ohio, a distance of about nine miles from the loading station.

The wagons used are of special design. The box is made of steel, and will hold about 3,500 lb. of garbage. It is hinged to the bolster over the rear axle, so that it can be dumped. It is, however, not self-dumping, the purpose being to keep as much of the load as possible to the front of the wagon. In order to dump it, chains are attached to the front of the box, and by means of a triplex block the front end of the box is raised sufficiently to permit the garbage to fall out at the rear, as shown in an accompanying illustration. The wagons are equipped with canvas covers, to hide the material and to prevent the noise usually made by wagons with iron covers.

A special design of railroad car, of which ten are provided, is used. The cars are constructed of steel throughout, and have standard-gauge trucks, with 33-in. wheels. The body of the car is a semi-circular tank, 30 ft. long. It is supported by trunnions at each end, and also by rollers at three different points underneath. In

order to unload the car, cables are passed through underneath the body and fastened at a point about half way from the top, then by means of two 5-ton triplex blocks the body is tipped so that the garbage falls out upon the floor of a receiving building at the works. Although the capacity of the cars is 40 tons each, only two men are required to tip them.

The arrangement of the buildings, tracks and so forth at the works is shown in an accompanying illustration. The railroad cars are run into a receiving building, where the garbage is dumped on a concrete floor. From this floor the garbage is shoveled into two conveyors, with 6 x 18 x 24-in. flights, which deliver it to the top floor of a digester building. These conveyors, which were installed by the Jeffrey Mfg. Co., of Columbus, Ohio, and all other machines are driven by separate motors, thus avoiding the use of main line shafts and belts. A 250-h.p. Monarch Corliss engine, direct-connected to a Triumph generator, furnishes power to operate the works. Steam is supplied from a boiler plant containing five 80-h.p. and two 150-h.p. return tubular boilers.

TABLE 2.—SUMMARY OF PRODUCTS, SALES AND INVENTORY.

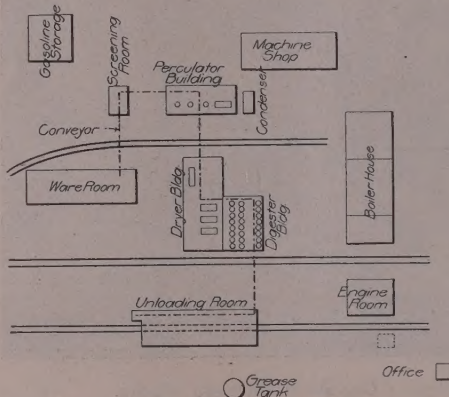
January 1 to July 1, 1906.			
Quantity.	Article.	Average Price.	Amount.
1,024,895	lb. grease, at.....	\$3.02 cwt.	\$30,976.49
3,048,610	lb. dry tankage, at.....	8.42 ton	12,849.16
285,460	lb. pressed tankage, at.....	2.926 ton	417.72
78	lb. hair, at.....	0.20 lb.	15.60
44	tails, at.....	0.313 each	13.80
258	hides, at.....	3.56 each	918.54
Total first six months, 1906...			\$45,191.31
July 1 to January 1, 1906.			
Quantity.	Article.	Average Price.	Amount.
1,115,380	lb. grease, at.....	\$3.76 cwt.	\$41,939.73
3,233,918	lb. dry tankage, at.....	8.487 ton	13,724.44
2,029,940	lb. pressed tankage, at.....	2.522 ton	2,563.70
473	lb. hair, at.....	0.20 lb.	87.40
151	tails, at.....	0.30 each	45.30
420	hides, at.....	3.55 each	1,493.04
Total last six months, 1906...			\$59,853.61
January 1, 1907, to July 1, 1907.			
Quantity.	Article.	Average Price.	Amount.
1,225,290	lb. grease, at.....	\$4.25 cwt.	\$52,068.44
2,756,281	lb. dry tankage, at.....	7.35 ton	10,816.14
2,439,010	lb. pressed tankage, at.....	2.47 ton	3,011.61
181	lb. hair, at.....	6.20 lb.	36.20
115	tails, at.....	0.30 each	34.50
220	hides, at.....	4.65 each	1,021.47
Total first six months, 1907...			\$66,988.36

The conveyors pass through the digester building in a horizontal position and drop the garbage through tubes directly into the digesters or tanks, where the same is cooked. Twenty-four digesters, each having a capacity of 10 tons per day, making the total daily capacity of the plant 240 tons, are installed. The digesters are 14 ft. high and 54 in. in diameter. When the digesters are filled, steam is turned into the material at a point near the bottom of the tank and the garbage allowed to cook from six to seven hours, 70 lb. steam pressure being used. When the cooking process is completed, the steam is shut off at the bottom of the tank and turned in at the top, the pressure thus produced driving off the free water and some of the grease through a draw-off pipe at the bottom. In order to prevent the material from passing out with the water, a strainer and strainer-plate are used. This mixture of water and grease is pumped into settling vats and allowed to cool, after which the grease is skimmed off the top. The solids remaining in the digester are removed through an opening in the side of the tank about 12 in. from the bottom and deposited in a small car, which is equipped with a worm conveyor, automatically unloading it into a drag conveyor that takes the material to the dryers. It is first put into a steam-jacketed dryer 14 ft. long and 5 ft. in diameter. This dryer has a shaft through its center with paddles attached. As the shaft rotates the paddles lift the material, breaking it up and at the same time evaporating some of the moisture. This type of dryer is equipped with two manholes underneath it, through which the material is dropped into still another conveyor and conveyed to a com-

bination steam and hot air rotary dryer, which was designed by Mr. E. S. Peck, superintendent of the plant. The cylinder of this dryer is 30 ft. long, 57 in. in diameter, with a 2-in. space between the inner and outer shell for the admission of steam. There is also a 14-in. steam pipe running through its center. To the sides of the inner shell are attached flights, 4 in. in width, which lift the material as the dryer rotates.

The dryer is set on a grade of a ¼-in. per foot, and the tankage (as the material is called) is fed in at the upper end and discharged at the lower, the process being a continuous one. At the lower end of the dryer is a series of steam coils with an attached blower, which forces the air around these coils, heating it to about 230 deg. Fahr. This dry air then passes through the dryer, absorbing the moisture from the tankage as it falls from the flights above referred to.

About 50 ft. distant from the dryer building is located the percolator building, to which the material is next conveyed, and where the grease is extracted by the use of naphtha. In the upper part of this building there are three bins for the storage of tankage. Under each of these bins is a tank 8 ft. high and 6 ft. in diameter, which is called a percolator. The material is put in through an opening in the top. When filled, the percolator is sealed and naphtha or gasoline is pumped in at the top and allowed to percolate through the material, being drawn off at the bot-



Arrangement of Buildings at Works.

tom and carrying with it the grease. The grease and naphtha flow to a treating tank in which there are steam pipes, where it is heated sufficiently to vaporize the naphtha and leave the grease in the tank. The vaporized naphtha passes through a condenser, restoring it to its liquid form, from which it flows back to the storage tank, and from which it is again pumped into the percolator. After all of the grease has been extracted from the material left in the percolator, the flow of naphtha is turned off, and in order to recover such of the naphtha still remaining in this material, steam is injected into the tankage, vaporizing and driving off the naphtha. This mixture of steam and naphtha vapor also goes to the condenser and thence to the storage tank. The water produced by the condensation of the steam is drawn off from the bottom of the storage tank.

To reduce the condensation of steam to a minimum, it is first admitted into the tank at a point near the top of the percolator. When the material above this point has been heated and the naphtha vaporized, steam is turned in at about the middle of the tank, and afterwards at the bottom, repeating the process until all the naphtha has been vaporized. The loss of naphtha by this system is about 2½ gal. to the ton of dry tankage. The openings in the percolator, through which the grease and naphtha escape, are covered with perforated plates and pipes designed to prevent carrying the tankage through same. The material is removed both from the side and the bottom

of the percolator, placed in a conveyor, and sent to a small building about 20 ft. distant, in which it passes through a hexagonal revolving screen, taking out rags, tin, pieces of crockery, glass, and so forth. From here the finished product is conveyed to the storage house and there loaded upon cars for shipment.

The taking out of the material from the above type of percolator and replacing the small perforated plates and pipes through which the grease escapes, involves considerable time and labor. Mr. Peck has invented a new type of percolator, which Mr. Springborn believes will overcome these objections, and at the same time greatly reduce the loss of naphtha and leave the material much dryer. This percolator is similar in de-

TABLE 3.—COMPARATIVE INCOME AND EXPENSE STATEMENT.

	Gross Income.	
	First six months, 1907.	1906.
For sale of product.....	\$60,514.61	\$41,655.27
For inventory of product.....	6,473.75	3,336.04
For sale of raw material, etc.....	237.50	79.66
For rents.....	46.00	64.75
For miscellaneous income collection department	318.95	1,240.43
Total income.....	\$67,590.81	\$46,376.15
Expenses at Reduction Works.		
Labor at plant.....	\$20,612.72	\$18,493.53
Coal at plant.....	9,050.57	7,861.70
Superintendence and clerk hire.....	1,721.70	1,712.50
Repairs and renewals to plant.....	5,396.03	2,271.03
Press cloth.....	1,267.65	968.86
Press racks.....	427.48	276.39
Insurance on buildings and boilers.....	124.50	144.37
Office supplies.....	104.47	74.52
Freight on product, purchase dead animals, etc.....	795.70	434.96
Oil, waste, light, telephone, water, etc.....	3,488.29	1,456.34
Taxes.....	193.40	149.77
Commissions, analysis, weighing, etc.....	325.91	396.99
Total expenses at works.....	\$43,508.42	\$34,150.96

Expenses at Loading Station.		
Labor, teamster, etc.....	\$25,180.77	\$19,278.97
Feed.....	7,896.94	5,548.65
Railroad freight on garbage.....	2,837.77	2,190.80
Superintendence and clerk hire.....	1,290.00	1,130.00
Shoeing, etc.....	1,480.65	1,200.99
Repairs and renewals to freight cars owned, wagons, etc.....	2,441.40	2,064.43
Repairs to harness.....	490.51	595.54
All other sundries not itemized above: Barn supplies, telephone, light, etc.....	1,673.95	657.16
Painting garbage cars and boxes.....		808.12
Insurance, rent, etc.....	224.94	460.82
Total expenses at loading station.....	\$43,516.93	\$34,635.48

Extraordinary Expenses.		
Audited.....	\$150.00	\$150.00
Loss on horses.....	400.00	1,082.50
For depreciation on machinery and equipment at plant, Willow, Ohio, at rate of 10 per cent per year.....	4,072.11	1,059.79
For depreciation on wagons, horses, stable and other equipment at Canal St. at rate of 10 per cent per year.....	2,105.43	1,600.53
Total extraordinary expenses.....	\$6,727.54	\$4,492.82

Total Expenses.		
At reduction works.....	\$43,508.42	\$34,150.96
At loading station.....	43,516.93	34,635.48
Extraordinary and depreciation.....	6,727.54	4,492.82
Total expenses.....	\$93,752.89	\$73,279.26
Total income.....	67,590.81	46,376.15
Net operating expense.....	\$26,162.08	\$26,703.11

sign to the dryer designed by Mr. Peck, except that it is but 14 ft. in length and 8 ft. in diameter. It is placed in a horizontal position, has a steam jacket, and is constructed to rotate in the same manner as the dryer. The material is put into this percolator through two manholes in its upper side. The pipes for the admission of gasoline are also connected through the covers in these manholes. The grease and naphtha escape through three openings in the lower part of the tank, and in order to hasten the process of percolation the pipes can readily be disconnected and the percolator rotated so as to mix thoroughly the entire mass of material with the naphtha or solvent used.

In order to recover the naphtha after the grease has been extracted, steam is turned into the drum and jacket and the percolator made to revolve, thus while heating the material, also moving the same sufficiently to release quickly all of the solvent contained in the tankage. By this method no moisture is added to the material nor steam mixed with the vapors, which go to the con-

denser and thence to the storage tank. By the use of this type of percolator, Mr. Springborn thinks that the loss of naphtha will not exceed 1 gal. per ton of material treated.

The naphtha storage building is constructed of concrete, the tanks being placed below the ground level, with only the roof of the building projecting above the surface.

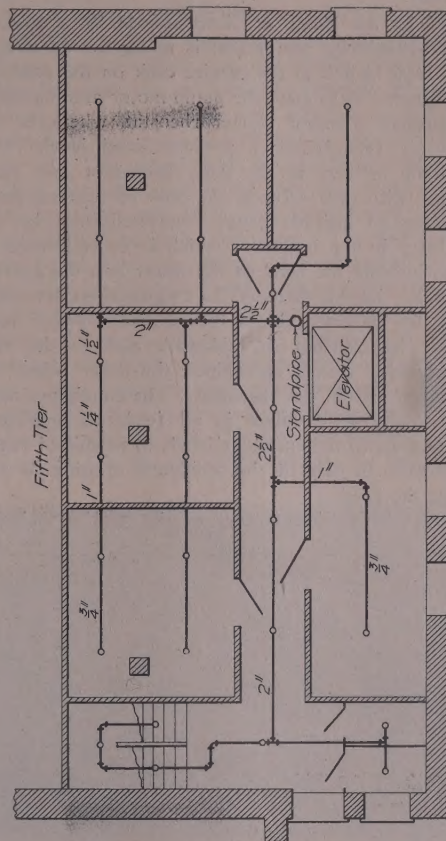
In the old process formerly used, the grease was extracted by means of hydraulic presses, the tankage being placed between burlap on racks in layers about 3 in. thick and 5 ft. square. The cylinder of the presses was 14 in. in diameter, and subjected to a pressure of 3,500 lb. to the square inch. By this means the liquids were squeezed out of the material, carrying the grease with same to a vat, where, after cooling and settling, the grease was skimmed off. The tankage produced by this method is not as desirable to the trade as that which is being made from the new process. There is about 12 per cent. of grease left in the pressed tankage, whereas in the other there is only about 2 per cent. The grease being the most valuable part of the product, makes it desirable to recover as large a percentage as possible.

During the year 1907, 37,606 tons of garbage were collected and reduced. The cost of doing the work was \$193,365.76. The gross income for sale of product, including inventory of material on hand and miscellaneous revenues, amounted to \$136,985.60, leaving, therefore, the sum of \$56,380.16 to be charged to taxes.

A summary of the gross income and expenses for the first six months of 1907 is given in Table 3, but the corresponding detail results for the last half of that year are not available. In this table, also, a comparison is made between the net operating expenses for corresponding periods in 1907 and 1906. The net operating expenses of \$26,162.08 for the first six months of 1907 is the difference between the net income and operating

Fire Protection in the New Forrest Theater, Philadelphia, Pa.

The new Forrest Theater, a modern playhouse with a seating capacity of about 2,000 that has recently been completed in Philadelphia, Pa., at Broad and Sansom Sts., is notable as a public

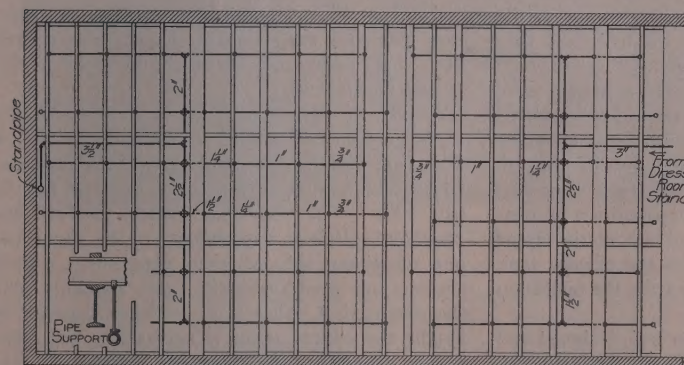


Sprinklers in Dressing Rooms.

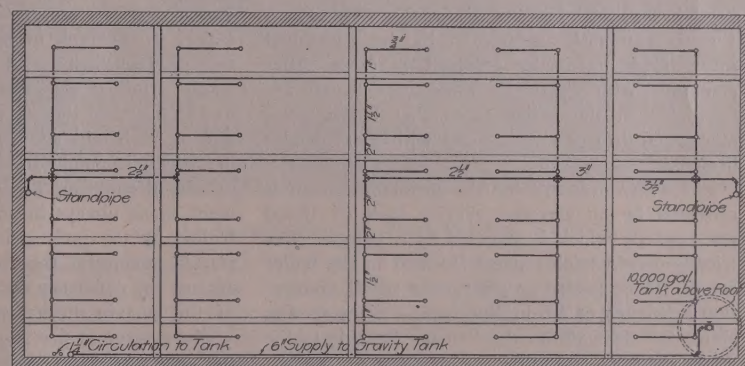
building in which unusual attention has been given to the comfort and safety of the patrons. The extensive system that has been installed for the heating and ventilating of the theater was described in an article in this journal for April 25, 1908. In details of construction, the structure has been made as nearly fireproof as possible, the Clinton system of fireproofing having been used throughout for all floor and roof construction, stairways, landings, forms for seats in the balcony and gallery, etc., while the walls are of brick and hollow tile. For protection from the danger of fire, a sprinkler system of fire protection has been installed in the stage division of the building, where the inflammable curtains and machinery must be provided for and stand pipes with racks of fire hose in the stage house and auditorium. The system of automatic sprinklers is of interest particularly for its conformity to the very rigid present requirements of the Underwriters.

The sprinkler system involves a total of 390 automatic sprinkler heads that have been distributed in accordance with the latest requirements of the Underwriters underneath the elevated roof over the stage, underneath the scenery gridiron, in the five tiers of dressing-rooms, in the two fly galleries, over the painter's bridge and in the basement underneath the stage division. The Phoenix type of head, supplied by the Phoenix Fire Extinguisher Co., Chicago, Ill., has been used in the installation which, except under skylights, are set for fusing temperatures of 160 deg. Fahr.; the heads located in the latter positions, where subject to the high temperatures resulting from the action of the sun, are fitted with links fused for 200 deg. The heads are of the standard Phoenix construction, designed for the discharge of about 20 gal. per minute when open and are in all cases tapped for 3/4-in. supply connections. As the building is kept constantly heated throughout the winter season, the sprinklers are operated on the wet pipe system throughout, the water pressure being supplied direct by standpipes to all heads.

The sprinkler heads have been distributed in



Arrangement of Sprinkler Heads under Stage.



Gridiron under Stage Roof of the Forrest Theater.

expenses, including depreciation for that period, without interest charges. It is, in fact, the cost to the city of Cleveland for the collection and reduction of 35,985,500 lb. of garbage.

The city is divided into sixty-seven routes, using in all about 80 wagons and 110 horses. During the last year of the contract (1904) there were collected 24,687 tons. In 1905, under municipal control, this was increased to 30,382 tons. In 1906 the collection amounted to 34,891 tons; in 1907 37,606 tons. At the same rate of increase the collection this year will amount to more than 40,000 tons.

Every effort has been made to recover a larger percentage of the valuables contained in the garbage so as to secure a greater return from the sale of by-products. The receipts to the city in 1905 from this source amounted to \$65,881.14; in 1906 it had increased to \$106,990.41; in 1907 to \$136,985.60. Not all of this increase is due to the larger percentage of grease and tankage recovered, but, as shown in Table 2, in part to better market prices which were secured in their sale.

building in which unusual attention has been given to the comfort and safety of the patrons. The extensive system that has been installed for the heating and ventilating of the theater was described in an article in this journal for April 25, 1908. In details of construction, the structure has been made as nearly fireproof as possible, the Clinton system of fireproofing having been used throughout for all floor and roof construction, stairways, landings, forms for seats in the balcony and gallery, etc., while the walls are of brick and hollow tile. For protection from the danger of fire, a sprinkler system of fire protection has been installed in the stage division of the building, where the inflammable curtains and machinery must be provided for and stand pipes with racks of fire hose in the stage house and auditorium. The system of automatic sprinklers is of interest particularly for its conformity to the very rigid present requirements of the Underwriters.

The system of fire protection is installed in the building under a classification of the Underwriters as a partial sprinkler equipment, auto-

matic sprinklers being installed only in the stage division where inflammable materials are kept and not in the auditorium or elsewhere in front of the proscenium wall. In the auditorium division there are only the usual stand-pipes for hose racks, there being a 2 1/2-in. standpipe on either side of the stage and a 2 1/2-in. standpipe on either side of the auditorium at the rear, each of which is connected with a 5,000-gal. elevated service tank that contains the water supply for the plumbing system, and has a hose rack at every floor level through which it passes, with control valve and 50 ft. of hose. This equipment including the hose racks, nozzles, etc., embraces approved apparatus throughout, but is, however, no different from the equipment of this class that is usually provided in theatrical buildings.

Owing to the comparatively small size of the fire areas covered, it was found feasible to supply the entire system from two risers which are 4-in.

standpipes, and arranged, one at the middle of either side of the stage space. Both are carried up as 4-in. risers to the highest level, that on the northerly side supplying the sprinkler branch mains in the five tiers of dressing rooms and one-half the heads under both the gridiron and the roof, while that on the southerly side supplies one-half of the basement space, the two fly galleries and the other halves of the gridiron and roof heads. The feeder and branch piping from the risers is run exposed in all cases, being suspended by iron rod hangers from the ceiling except under the gridiron where they are hung by turn-buckle rods which are clamped to the under flanges of the 8-in. longitudinal I-beams on which the iron gratings rest. The branch lines are run tapering in accordance with the number of heads connected, the pipe sizes ranging from a minimum of $\frac{3}{4}$ in. for a single head up to 1 in. for two heads, to $1\frac{1}{4}$ in. for three heads, to $1\frac{1}{2}$ in. for five heads, 2 in. for groups up to 10 heads, $2\frac{1}{2}$ in. for groups up to 20 heads, 3 in. for groups containing up to 36 heads and $3\frac{1}{2}$ in. for branches containing over this latter number. These proportions of feeders and branches are such as to prevent an excessive drop in pressure in any part of the system if a number of heads should open simultaneously. For signalling to the engineer the location of the feeder branch in which a sprinkler

The fire pump is a Goulds triplex pump of 250-gal. capacity, which was selected in preference to an Underwriter's steam fire pump of the usual type, owing to the fact that the difference in the insurance rates that would result from the installation of the latter, was not sufficient to justify the owners for going to such additional expense.

The fire pump is direct driven by a 10-h.p. Westinghouse motor that is under the control of a tank switch in the service tank on the roof, so adjusted as to start the pump motor automatically through a motor starter rheostat, whenever the water falls below a predetermined level. The pump delivers to the tank through a 4-in. riser line with gate valve at the tank connection, there being an altitude gauge connected into the delivery in the basement which is so calibrated as to indicate the level of the water into the gravity tank. To this delivery riser connections are made in the basement from the Siamese steamer plug on the Sansom St. sidewalk and to the two sprinkler system standpipes, the latter being fed upward from the basement. The standpipes have indicator gate valves in all feeder branch connections to the sprinkler heads to permit of ready closure in case of the accidental opening of any of the heads.

An interesting feature of the gravity tank in-

Mill B of the Pacific Portland Cement Company, Con., near Suisun, Cal.

By F. D. Wood.

Mill B of the Pacific Portland Cement Co., Con., which has been in operation since the early part of 1907, is located about a half-mile from Mill A, which was described in The Engineering Record of Aug. 30, 1902. Mill A has been enlarged since the article referred to was written, increasing the capacity to 2,200 bbls. per day, produced from eight 6 x 60-ft. kilns and three 7 x 80-ft. kilns. Mill B has a rated capacity of 2,500 bbls. per day and is so designed that any enlargement necessary to supply the market can be made by the addition of more kilns and grinding machinery and the extension to the present buildings.

All the buildings of the plant are the mill-type steel construction with corrugated-iron roof and sides. Where partitions are found necessary they are either hollow concrete blocks or corrugated iron. All bins, elevating and conveyor casings and machinery supports are of steel, making the entire plant fireproof.

The cement is made from two raw materials, limestone rock and clay. The rock is crushed in the quarry and dried and ground in the ball mills before mixing with the clay. Ball mills



General View of Buildings of Mill B of the Pacific Portland Cement Company.

head has opened in case of fire or otherwise, a Phoenix automatic alarm valve has been installed in each of the feeder connections from either standpipe with electrical connections to an annunciator in the boiler room that has a gong alarm and drops to correspond with every feeder branch.

The water pressure for the sprinkler system is provided by an elevated gravity tank of 10,000 gal. capacity which is supplied by a 250-gal. electrically-driven triplex pump, located in the boiler room. There is also an emergency supply connection consisting of a 6-in. line from a Siamese plug above the sidewalk on the Sansom St. side to the pump delivery riser for the purpose of permitting fire engines to pump into the system in case of fire. The tank is of wooden construction mounted on a structural steel tower above the stage house roof of such height that its base is 20 ft. above the highest sprinkler head under the stage roof. Its capacity of 10,000-gal. in constant storage is sufficient to supply 25 of the sprinkler heads for the required interval of 20 min., which number is considerably more than 25 per cent. of the total number of heads in any fire area covered. An unusual arrangement was made in this installation to prevent freezing of the water in the gravity tank, consisting of the application of a hot water circulation system in place of the usual steam coil installed in the tank, as is usually required. A water back has been fitted in the furnace of the heating boiler in the basement, from which $1\frac{1}{2}$ -in. flow and return pipes are carried up to the tank above the roof to cause partial heating of the water in the latter by means of the gravity circulation that will result as in the case of the ordinary house range tank for hot water supply. It is said that satisfactory results have been obtained during the past winter, no trouble having been experienced from freezing.

stallation is the use of the upper 2,000-gal. of the supply in the tank to operate the hydraulic curtain mechanism by means of which the fire-proof stage curtain is manipulated. The static pressure of the water in this upper portion of the tank is, due to its height above the stage level, about 30 lb., which is ample for the operation of the hydraulic mechanism. The electric pump in the basement, being always in operative condition as controlled by the tank switch and automatic motor starter, maintains the supply in the gravity tank against the deficiency resulting from the operation of the curtain mechanism.

The system of fire protection was designed and the equipment was installed by the Malcolm W. Hill Co., Philadelphia, Pa., the design having been approved by the Philadelphia Fire Underwriters' Association before installation. The sprinkler heads and alarm valves were supplied by the Phoenix Fire Extinguisher Co., Chicago, Ill. The standpipes that were installed in the auditorium division with the racks of hose at every floor level, were installed under the plumbing contract for the theater, by Mr. Alexander Barclay, Philadelphia.

THE WATER-TIGHTNESS of the concrete walls of the Cornell University water purification plant, constructed by Tucker & Vinton about three years ago under the direction of Prof. Gardner S. Williams, is an indication of what can be accomplished with careful workmanship. The coagulation basin has walls 15 in. thick and their bottom is under a head of 22 ft. continuously. The slight percolation through the tank that was present when it was first put into service has practically disappeared, and throughout the 60 ft. of length of the wall where the concrete is exposed, there is now scarcely a perceptible sign of leakage.

and tube mills are used for grinding both the raw materials and clinker. Rotary dryers and kilns, both using oil for fuel, are utilized for drying and burning.

Conveying Machinery.—Screw conveyors and bucket elevators, supplied by H. W. Caldwell & Sons, are installed for conveying both raw materials and clinker after being reduced by the ball mills. The conveying system in both the raw and clinker department is in duplicate, one on either side of each department. Both systems are used ordinarily, each handling half the output; but either is of sufficient capacity to handle the entire output if necessary. Belt conveyors, furnished by Stephens Adamson Mfg. Co., are used for handling the rock and clay before drying and 18 x 24-in. Peck bucket carriers, furnished by the Link Belt Co., of Chicago, are provided for handling the rock and clay after drying; also the clinkers from the coolers.

Quarry.—The quarry is located about one mile from the mill and contains an unlimited quantity of travertine rock which has been subjected to an upheaval since deposition and is very pure carbonate, which has been deposited from water carrying it in solution. The rock outcrops over a large area, with practically no soil covering it. The composition is very uniform, as shown by the following percentage analysis: SiO_2 , 1.25; Fe_2O_3 and Al_2O_3 , 1.00; CaO , 53.65; MgO , .55; ignition loss, 43.40.

The clay used is an aluminated buff to gray, which is soft and plastic and fuses at a moderate heat. It is free from quartz and contains no perceptible grit. The beds have been elevated and are somewhat crumbled. In the present workings the strata stand vertically and there is no stripping, as the clay extends to the grass roots. The clay is late tertiary age, an average percentage analysis of it being as follows: SiO_2 ,

58.25; Al_2O_3 , 18.56; Fe_2O_3 , 7.35; CaO , .85; MgO , 2.10; alkali, 2.29; ignition loss, 8.55.

An average percentage analysis of cements produced from these raw materials is as follows: SiO_2 , 22.25; Al_2O_3 , 7.65; Fe_2O_3 , 3.35; CaO , 62.38; MgO , 1.46; So_2 , 1.19; ignition loss, 1.02.

The rock at the quarry is loaded on low iron flat cars, the body of which is not over 10 in. above the ground. The tracks are laid on a slight grade and the loaded cars coast to the crushing plant, which is about 400 ft. from the south end of the quarry. Two electric mining-type locomotives, each equipped with a 10-h.-p. direct-current motor, haul the empty cars from the crushing plant back to the quarry face.

Crushing Plant.—The crushing plant consists of one No. 9 and one No. 6 Gates crusher with a revolving screen $2\frac{1}{2}$ ring taking the fines from the No. 9 and sending the tailings to the No. 6. The entire equipment at the crushing plant is driven by a 200-h.-p. motor. The electric railroad handling the rock from the storage bins at the crushing plant and the clay to the mill is a 36-in. gauge overhead trolley. The equipment consists of 24 steel hopper-bottom 12-ton capacity dump cars and two Baldwin-Westinghouse Class 8-4E locomotives, each having a 50-h.-p.,

conveyors feeding the same are driven from a line shaft, power being supplied by a 40-h.-p. motor.

Rock and Clay Grinding.—From the dryers the rock is conveyed and elevated by Peck carriers to bins over six No. 8 Krupp ball mills located on the next terrace, 10 ft. below the dryer terrace. From the ball mills ground limestone passes to four storage bins of the Berquist patent type, each holding about 150 tons. The ball mills are driven by belts from two line shafts, power being furnished by a 300-h.-p. General Electric motor operating at 514 r.p.m., which is located in a small power room at one end of the ball mill terrace. This power room also contains a switchboard from which all lights and the motors driving conveyors and elevators in stone house, dryer and ball mill room are controlled. The clay from the dryers passes by means of Peck carrier to a 9-ft. dry pan equipped with $\frac{3}{16}$ -in. mesh screens located at the east end of the ball mill terrace. From this the ground clay is conveyed to four storage bins with the same capacity and of the same type as used for ground limestone.

Mixing.—A 12-in. screw conveyor under the Berquist storage bins for ground limestone and clay conveys the materials forward to two sets

the clinker passes by a Peck carrier and pan conveyors to bins over clinker ball mills.

Clinker Ball Mills.—Six No. 8 Krupp ball mills and one Lindhard No. 66 kominuter are provided for grinding the clinker. These machines are located at the same level and are separated from the clinker pit by a corrugated-iron partition.

Clinker Tube Mills.—Separated from the clinker ball mills by the lower power house, is a 73 x 192-ft. clinker-tube mill building, containing nine No. 16 Davidson tube mills and nine Emerick separators. Eight of these tube mills are in batteries of four, driven from two-line shafts, the same as the raw tube mills. The ninth mill is belt-driven from a line shaft, power being furnished by a 125-h.-p. motor. Foundations for ten tube mills were put in when the mill was constructed, but only nine mills were installed pending the development of the plant. Two separate conveying systems are installed in the clinker tube mill building, one for conveying the material from the mills to the separators and from the separators to the stock house, and the other conveying the material from the tube mills direct to the stock house in case the separators are not running.



Battery of Raw-Materials Tube Mills.

Arrangement of Drive for Ball Mills.

550-volt, direct-current motor on each of the four axles. The grade from the quarry to the mill is 6 per cent. in favor of the loads. All cars are equipped with Westinghouse air brakes and the locomotives have the new E-T Westinghouse brake equipment, straight and automatic air.

The clay is procured from a pit located midway between the quarry and the mill and is dug by Allis-Chalmers 40-ton steam shovel with a one-yard dipper. Seven-ton side-dump cars carry the clay from the pit to a 9-ft. dry pan by means of a single-drum hoist, equipped with a 40-h.-p. variable-speed Westinghouse motor.

Stone House.—The stone house where the rock and clay are received consists of 18 circular steel tanks 20 ft. in diameter and 40 ft. high. Nine of these tanks, with three in a row, on the west side are for rock and the similar arrangement on the east side for clay. Trains from the clay pit and quarry running overhead dump the rock and clay direct into the tanks, which have a capacity of one week's storage of rock and about three weeks' storage of clay.

Dryers.—On the next terrace with an elevation 15 ft. below the stone house, are located the four dryers, each 50 ft. long and 5 ft. in diameter, which were manufactured by the Vulcan Iron Works. Two of these are for rock and the other two for clay. The dryers, elevators and the belt

of Richardson tandem automatic weighing machines. The two sets of machines are used ordinarily, but if anything happens to one set the other is ample to handle the output. A mixing conveyor, consisting of two 16-in. cut flight screw conveyors, running in one casing, conveys the material to distributing conveyors over the tube mill bins.

Raw-Materials Tube Mills.—Eight No. 16 Davidson tube mills, manufactured by the F. L. Schmidt Co., are provided for finish grinding of raw materials. These mills are in batteries of four driven by belts from two-line shafts. The building housing the tube mills has been made large enough to accommodate two more mills if found necessary for the present output of kilns.

Kilns.—Separated from the tube mills by the main power house, but on the same level, is the kiln room, which contains 10 kilns, nine each, 7 x 80-ft. and one 8 x 100-ft. These kilns were manufactured by the Vulcan Iron Works. Each kiln is driven by a 15-h.-p. variable-speed General Electric 440-volt motor, having a 100 per cent. speed variation. These motors are located in the tunnel under the kilns away from the heat and dust. The kilns are fed by 9-in. screw conveyors located under the kiln bins which discharge into a water-jacket feed pipe. Upright 8 x 32-ft. coolers, manufactured by Mooser & Co., are provided for cooling the clinker. From these coolers

Stock House.—The stock house is a 124 x 180-ft. building, with eighteen reinforced-concrete bins each 24 x 32 ft. in plan and 22 ft. high, holding about 4,500 bbls., or a total storage of 80,000 bbls. These bins are arranged in rows of three each with an aisle between in which the conveyors and shafts driving bin conveyors are located. The packing equipment consists of five automatic weighing machines manufactured by the Automatic Weighing Machine Co., which are set on a raised platform about 3 ft. high. In front of this platform is installed a 24-in. flat-belt conveyor, which can be run in either direction, carrying the filled sacks to either side of the stock house where the cement is trucked into cars. If the sacked cement is to go to storage houses a scraper slides the sack off the belt and deposits it on one of the six 24-in. flat-belt conveyors, which are inclined until they reach a height of about 16 ft., and then run level the full length of the storage houses.

Storage Houses.—There are two sack storage houses, each 90 x 112 ft. in plan, with three 24-in. flat-belt conveyors overhead to distribute the sacks. These two houses have a storage capacity of 40,000 bbls. when sacks are piled 25 high. An additional sack storage is in the course of erection which will double this capacity.

Power.—The entire equipment of the mill is electrically driven by three-phase, 60-cycle induc-

tion motors, power being supplied by the Bay Counties Power Co. from the hydro-electric development of that company on the slope of the Sierra Nevada Mountains. The power at 60,000 volts is delivered at a sub-station located on the Pacific Portland Cement Co., Con., property, about 1,000 feet from Mills A and B. At this point it is transformed down to 2,080 volts and delivered at this latter voltage to a switchboard in the main power house. All motors throughout the mill of 30 h.-p. capacity or above are 2,080 volts, machines all under 30 h.-p. are designed to operate at 440 volts.

Main Power House.—The main power house is located between the raw tube-mill and the kiln buildings, being separated by 6-in. hollow concrete-block walls. The building is 29.5 x 192 ft. in plan, with a five-ton capacity overhead crane. In this building are two 400 h.-p. Westinghouse motors, operating at 192 r.p.m. and direct-connected to the line shafts driving the raw tube mills by means of 600 h.-p. Pelton flexible couplings. Three Root blowers geared to 85 h.-p. motors furnish air for the kilns; and a motor-generator set furnishes power for the electric road from the quarry. This set consists of a 580-h.-p. type C X, 2,000-volt, alternating-current

all the motors driving the ball and tube mills as follows: Two 400-h.-p. Westinghouse motors, direct-connected to line shafts driving the tube mills, the same as in the main power house; one 125-h.-p. General Electric motor driving one tube mill, and two 225-h.-p. General Electric motors belted to line shafts driving the ball mills. The electric equipment in the lower power house as well as lights and distribution of power to clinker mills, is controlled by a nine-panel switchboard located at the west end of the building. This board is in two halves with two separate leads from the main power house.

Store Room and Machine Shop.—The machine shop, store room, carpenter shop and belt-making room are all under one roof separated by corrugated iron partitions. The building is 52 x 106 ft. in plan, with wooden trusses and purlins, covered sides and a roof of galvanized corrugated iron. The machine shop contains only the following small machines: A Bickford 36-in. radial drill; one 24-in. Queen City shaper, and one Lodge & Shipley 18-in. lathe; an Acme belt cutter, a power saw, a wall drill and a blacksmith's forge. All large machine tools are in the shop at Mill A.

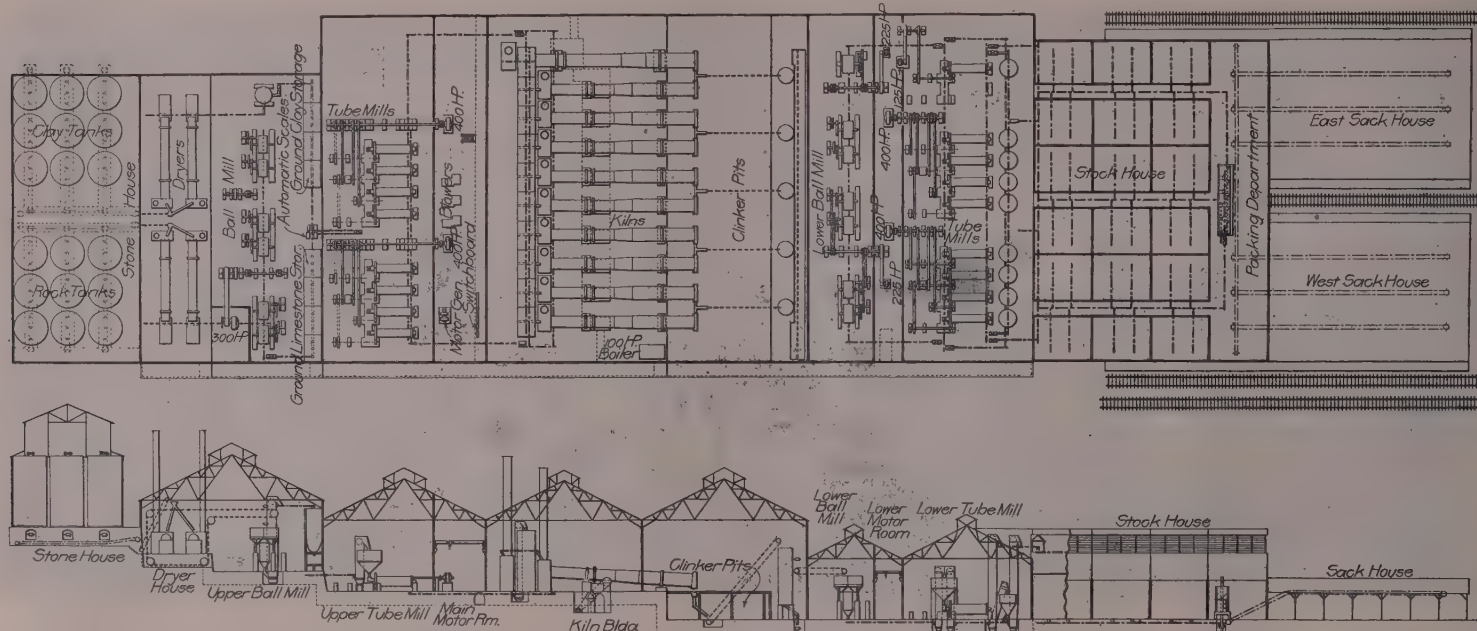
Fuel Oil.—The fuel oil is received by the Stand-

water, electric lights, long distance telephones and a complete sewage system.

The officers of the Pacific Portland Cement Co., Con., are: Messrs. Wakefield Baker, president; F. Drum, first vice-president; R. D. Robbins, second vice-president, and N. L. Bell, secretary. The designing and construction of Mill B were in charge of Morris Kind, general superintendent, assisted by Wm. J. Moore, in charge of the engineering department, and the writer, who was constructing engineer.

A Long Ropeway in the Argentine Cordilleras.

A ropeway 21½ miles long has been built in the North Argentine Cordilleras to carry supplies, ore and passengers between the mines of the Fomatina district and Chilecito, the nearest railway terminus. The difference in elevation between the two terminal stations is 11,500 ft. The calculated capacity of the line downhill is 40 tons per hour, and uphill 4 tons per hour. The speed is about 500 ft. per minute. The cars loaded weigh 1,100 lb. and are placed at intervals of about 370 ft. The line is down-grade from the mines, an important item in transporting the



Plan and Sectional Elevation of Buildings of Mill B, Pacific Portland Cement Company.

Westinghouse motor operating at 500 r.p.m., a 400-h.-p., 550-volt, direct-current Westinghouse motor. The operation of the various electrical equipment in the power house and the distribution of power to the lower power house and sub-boards in other buildings, is controlled from a 19-panel switchboard, located at one end of the power house. This board has two panels on the west end, on which are mounted the two main switches of the Bay Counties Power Co.; also their meters and recording wattmeter. Next to these is the totalizing panel containing the ammeters, voltmeters and recording wattmeter. The other 16 panels are for the different machines in the power house, for lights, and so forth. All the power wires, auto-starters, transformers and compensators connected with this board are in a tunnel below extending across the power house. This tunnel joins into a larger tunnel running the entire length of the mill on the west side, which accommodates all power lines, telephone and light wires, water, oil, steam and compressed air pipes, in addition to terra cotta sewer and drain pipes.

Lower Power House.—The lower power house is located between the clinker ball and clinker tube mills, from which it is separated by a concrete block wall. It is provided with an overhead crane the same as in the main power house. The building is 16 x 192 ft. in plan and contains

ard Oil Co.'s barges at Suisun, a small town about 6 miles from the works, located on a slough leading into San Francisco Bay. These barges discharge into a 400,000-gal. storage tank at the pumping station. From this storage tank the oil is pumped through a 6-in. pipe to a concrete reservoir, with a capacity of 150,000 gal., that is located on sidehill back of the mill.

Railroad.—Mills A and B are about 2½ miles from the Southern Pacific R. R. and the Pacific Portland Cement Co., Con., operates its own road joining the Southern Pacific at a station called Tolenas. The equipment consists of three locomotives, one coal burner and two oil burners. The line leading to Mill B terminates with three switches to the stock house and one to the center between the two sack houses. This allows 17 cars to be placed for loading without switching. A switch on the west stock house track leads to the store room and extends along the entire west side of the wall. A two-ton stiff-legged derrick, with a double-drum electric hoist, is located below the store room for handling all heavy machine parts.

Village.—Since the new Mill B was projected the village called Cement has been enlarged by the addition of 25 cottages and commissary, and a hotel of 100 rooms, for the convenience of mill operatives. All the cottages are supplied with

large quantities of silver and copper ore to the railroad. The contractors for the line were Adolph Bleichert & Co., of Leipzig and London.

The line has been divided into eight operating sections, each with an independent traction rope. Those sections on the lighter grades are naturally the longer ones, one of the sections nearest Chilecito being 5.6 miles long with a rise of 1,522 ft., and another 5¼ miles long with a rise of 1,512 ft. On the first of these sections the River Amarillo is crossed with a span of 1,525 ft. The longest span, according to "Engineering," London, is about 2,950 ft. The steepest section has portions on grades up to 45 per cent. At one point a tunnel 492 ft. long was necessary in order to avoid having too sharp an angle in the rope. In order to cross mountain tops with a large radius for the rope, deep cuttings were sometimes necessary, one of them containing about 7,200 cu. yd.

The towers supporting the carrying and traction cables are of steel and vary in height from 10 to 131 ft., though most of them are between 20 and 33 ft. The average spacing of the supports on level stretches is about 325 ft. Because the line broke through an entirely new country it was necessary to carry the heavy wire ropes to place beyond the last completed section by porters, from 40 to 100 being used for a single rope, depending on its length and other conditions.

The Water-Supply System of Seattle, Wash.

The water supply of Seattle, Wash., is obtained from Cedar River through a conduit, 26 miles long, that delivers to reservoirs in the city. These reservoirs are at such elevations that practically all of the distribution mains are supplied by gravity from them, although some of the residential districts on the highest hills are under pressure from stand-towers, to which water is pumped from the reservoirs. The supply and distribution systems are municipally owned and operated, and the city also owns large areas of land on both sides of the river above the intake of the conduit. The existing supply system was placed in service in 1901, at which time the capacity of the conduit was 60 per cent. in excess of the demands on the distribution mains. The growth of the city since then has occasioned such an increase in the amount of water necessary that large extensions of the supply and distribution systems have recently been undertaken according to the general

the sea level, but has been raised 13 ft. by the construction of a timber dam across the river one-half mile below the lower end of the lake. At the present water level the lake covers an area of approximately 1,200 acres and is of great depth over practically this entire area. The lake is in a very rough, precipitous region, with mountains rising abruptly on all sides of it to elevations of 3,000 to 6,000 ft.

A heavy fall of snow occurs in the winter on the summit of these mountains, and this snow melts gradually during the summer until it is finally dissipated by rains in the early fall. The deficiency of rainfall during the summer is thus made up by the run-off from these snow fields. The water from the latter is perfectly clear and free from the turbidity which accompanies the water from glaciers. The slopes of the mountains are also covered with a dense growth of large timber that greatly regulates the rate of run-off. At the same time the mountain slopes and all the region around the lake are entirely

the watershed. During the past two years, the Chicago, Milwaukee & St. Paul Ry. has located and been constructing a line which reaches the Cedar River immediately below the power station and then follows down that river beyond the intake of the conduit, with eight miles of this line inside the water-shed and close to the river edge.

The possibility of the pollution of the supply during the construction, and afterwards from the trains operated over this railroad is, of course, very great. The entirely new conditions in the state of Washington presented by the construction of this railroad were investigated by a commission to determine the possible effect on the supply and the best means of preventing the contamination of the latter. This commission found that if proper precautions were enforced during the construction work and in the operation of trains, that the river would be practically free from dangerous pollution. Based on this finding, an agreement regulating the maintenance of construction camps and the operation of the railroad within the watershed was reached between the city and the railroad. This agreement was made against the most positive protest of Mr. Thomson. The construction work is now in progress, under strict supervision of the State Board of Health, according to the regulations of this agreement, and it is expected to enforce the regulations concerning the operation of trains.

The possibility of preventing contamination of the river by the enforcement of the regulations adopted after the railroad is in operation remains to be seen. At any rate, the presence of the railroad offers a serious menace to a considerable part of the water supply available from the Cedar River. It might be considered possible to remove this menace entirely by filtration, or other means of purification. The value of a water supply such as is obtainable from a virgin stream of this kind on the western slope of the Cascade Mountains is difficult of appreciation by those not accustomed to the character of these streams. Indeed, it is reasonable to believe that people who have used such water for any length of time would not use filtered water so long as an unpolluted virgin supply could be obtained.

Seventy-five square miles of the total watershed of the river above the intake of the conduit is above the point where the railroad reaches the river. The rainfall conditions on this portion of the watershed are such, however, that the portion of the supply affected by the presence of the railroad is not in the same ratio as the percentage of the watershed that is affected. The volume of flow at the dam built to raise the level of Cedar Lake varies considerably, but averages about 400 cu. ft. per second throughout the year. Measurements made at a weir at the intake of the conduit show that the average flow of the river throughout the year at that point is about 630 cu. ft. per second, indicating that approximately two-thirds of the supply available remains in its practical virgin condition. Since the city owns in fee all riparian lands in the watershed around and above the lake and along the river and its principal tributaries, the opportunity is afforded to restrict, or prohibit the use of that portion of the watershed above the power station for purposes from which direct pollution might otherwise result in the distant future. State laws will also doubtless eventually give all the rights necessary to protect the remainder of the watershed.

The plans for the development of the Cedar River as a source of supply contemplate the eventual construction of a high dam between the power station and the existing timber dam near the lower end of the lake. This high dam will be built in a narrow gorge through which the river flows, at a point where a solid rock foundation is obtainable. By carrying the dam to a height of 150 ft. the level of the lake can be raised 90 ft. and the water area of the lake nearly doubled. The con-



A Freshet over Temporary Dam at Lower End of Cedar Lake.

plan developed at the time the original works were built.

The Cedar River has its source on the western slope of the main range of the Cascade Mountains, near the summit of the latter and about 60 miles from Seattle. The river has a catchment area of 146 sq. miles above the intake of the existing conduit through which water is delivered to the city. The rainfall in this catchment area, like that along all of the western slopes of the Cascade Mountains, is remarkably heavy. Records in that part of the catchment area above the intake show an average annual rainfall of more than 100 inches on the upper half of the watershed, while at the summit of the mountains the amount of precipitation is much heavier. Practically all of the rainfall occurs between the 1st of October and the first of July, as July, August and September are almost devoid of precipitation. The character of the water-shed is such, however, that a comparatively large flow occurs during the summer, and opportunities are presented to conserve the flood flows, so a large amount of water is available for use throughout the year.

Cedar Lake, a natural body of water, 3.5 miles long and averaging three-quarters of a mile in width, is formed in the river in the mountains some 14 miles below the summit of the latter. This lake is in many ways a remarkable factor in the character and quantity of water that can be obtained from the river. The original level of the lake was at an elevation of 1,530 ft. above

uninhabited. In fact, few people ever go into the region immediately adjacent to the lake, and conditions are such that this region can never be inhabited. The city owns the entire shore line of the lake and lands along the Cedar River and the Rex River, another stream which delivers into the lake, so in case it should eventually become necessary the supply can be entirely protected from contamination from these lands. The balance of the watershed above the lake has been withdrawn from sale by the general Government. Besides the conditions favorable to obtain a large supply of excellent water from this lake, the location of the latter is such that no algæ growths occur in water stored in it, and other undesirable storage conditions are also entirely absent.

A municipal hydro-electric station has been built by the city three miles below the timber dam that was erected to raise the level of the lake. Between this dam and the power station the river drops 600 ft. through a succession of rapids and sheer leaps. The intake of the present conduit is 11 miles below the power station, the fall in this distance being not quite 400 ft. The slope of the river is, therefore, much flatter between the intake and the power station than it is between the latter and the lake, although the valley in which it is located drops away quite rapidly. The character of the water-shed from the power station to the intake of the conduit, at the time the works of the first part of the supply system were completed, was generally the same as the upper portion of

struction of this dam will enable almost the entire run off of the catchment area of the river above the site of the dam to be rendered available for use as is desired. From this total run off an average flow of 280,000,000 gal. per 24 hours can be maintained throughout the year. The value for municipal purposes of such a quantity of water of the character that is obtainable from the Cedar River above this point is extremely great and this supply is capable of development at a very low cost. At the same time, the entire volume of water conserved will be available for use in a hydro-electric development at or adjacent to the existing station before the water is diverted into conduits leading to the city.

The intake of the present conduit is at one end of an over-flow timber dam having a spillway crest 125 ft. long. The abutments of this dam are of concrete and the entire structure is of a quite permanent character. The conduit is twenty-six miles long, and is laid to a uniform hydraulic grade equated for the difference in flow through wood-stave and riveted steel pipe, of which the conduit is built. About 9 miles of the conduit out of the 26 miles is riveted-steel pipe, the balance being wood-stave pipe. The latter is used up to a maximum head of 220 ft., the steel pipe making up the conduit when heads in excess of

Queen Anne Hill, a residential section of the city at a maximum elevation of 520 ft. Water is also pumped to a third elevated water-tower on a hill near the Volunteer Park reservoir. The high-level service distribution mains are supplied by gravity from these three elevated stand-towers. The power of the water flowing from the Volunteer Park reservoir to the Lincoln Park reservoir is utilized to pump water from the latter to the three elevated stand-towers. A substantial concrete pumping station building has been erected at the Lincoln Park reservoir to house the equipment required to utilize this power and the pumps which deliver to the elevated towers. Two 10x12-in. Gould triplex pumps are erected in this station, each pump being geared to a Pelton tangential water wheel. The water from the Volunteer Park reservoir is delivered to the wheels at a head of 108 ft. and the pumps are each capable of delivering 1,500,000 gal. per 24 hours against a pressure of 100 lb. per square inch. Since the volume of water delivered to the Lincoln Park reservoir is greatly in excess of that required to be pumped to the towers on Queen Anne Hill, sufficient power is at all times available to operate these pumps.

The stand-tower in Volunteer Park is a steel tank, with a capacity of 800,000 gal., which is en-

The new conduit will extend beyond the Beacon Hill reservoir to the Volunteer Park reservoir, a distance of four miles, as a 48-in. line, and thence for four miles further as a 42-in. line to a 50,000,000-gal. distribution reservoir in the northern end of the city. This latter reservoir will be at an elevation of 420 ft. above tide, so a section of the intermediate service in that end of the city can be supplied from it. Another 50,000,000-gal. reservoir is to be constructed adjacent to it at an elevation of 308 ft. to furnish pressure to a section of the low-service system in that locality.

Additional general plans for the development of the Cedar River and its tributaries to obtain a supply for a large metropolitan city have been carefully prepared, and most of the work that has been done, or that is immediately contemplated will form a part of these general plans. Surveys have been made for a conduit to start a short distance below the hydro-electric station on the river, at an elevation of 810 ft. and to extend to Walsh Lake, a body of fresh water, covering at present about 400 acres, that is near the intake of the present conduit, but at a considerably higher elevation than the latter. This lake will be developed as a storage and regulating reservoir for the supply system. A conduit will be built from it to a reservoir site at an elevation of about 700



Map Showing Watershed of Cedar River and Pipe Line from Intake to Seattle.

that amount are encountered. The carrying capacity of the conduit is 22,500,000 gal. per 24 hours.

A setting basin was placed in the conduit 2,600 ft. below the intake to intercept such sand and gravel as may pass through screens at the intake during freshets. This basin is a concrete structure, 25x90 ft. in plan and 25 ft. deep. The bottom of the basin is depressed 16 ft. below the invert of the conduit and is divided by transverse walls into three chambers, each sloped to a blow-off on the river side. Air valves and blow-offs are placed in the conduit between this basin and the city at such points as are necessary.

The site of the city is particularly rough and hilly, elevations within it varying from tide level to a height of 500 ft. above that level. On this account, the distribution system is divided into three separate services. Areas from tide level to an elevation of 225 ft. in which the business sections are all included, are supplied from a low-service system; an intermediate system supplies areas at elevation between 225 and 325 ft. and the portions of the city above the 325 ft. contour are served by a high-level system.

The conduit delivers to a 24,000,000 gal. reservoir in Volunteer Park, near the center of the residential district, the water level in this reservoir being at an elevation of 420 ft. above tide. A portion of the supply is diverted from this reservoir through a 36-in. line, about a half mile in length, to a 24,000,000-gal. reservoir in Lincoln Park, in which reservoir the water level is at an elevation of 312 ft. above tide. The low-service system is supplied by a gravity from the Lincoln Park reservoir; the intermediate-service system is supplied by gravity from the Volunteer Park reservoir. Water is pumped from the Lincoln Park reservoir to two elevated water-towers on

closed in an ornamental brick structure designed to be in keeping with the surroundings. Water is also delivered to this tower during periods of excessive draft in the summer from Volunteer Park reservoir by a 3,000,000 gal. centrifugal pump, direct-connected to an electric motor. The three stand-towers float on the high-level service, the water entering and leaving them in each case through the same connection to the mains of that service.

The additions to and extensions of the supply system which are to be undertaken immediately consist of a conduit paralleling the existing one from the intake to a point four miles south of the Volunteer Park reservoir. This conduit will have a total length of 32 miles and will extend to the extreme northern portion of the city. The conduit, which it to be laid throughout to a hydraulic grade, will consist of wood stave pipe up to heads of 300 ft. At such points as that amount of head is exceeded steel pipe will be used. The first 12 miles of the line is to be 60 in. in diameter, while the next 12 miles can be made 50½ in. in diameter, owing to a steeper grade that is obtainable. At the end of this first 24 miles the conduit will deliver to a pair of 50,000,000-gal. distribution and storage reservoirs to be built at an elevation of 312 ft. on Beacon Hill, the latter being immediately in the rear of rapidly growing business districts and in front of large and developed residential areas. These reservoirs are considerably below the hydraulic grade line of the conduit, so the flow in the connection leading to them from the conduit will be regulated by a differential valve. Water will be delivered from these reservoirs to the portion of the low-service system supplying the business section of the city, and to the adjacent residential districts.

ft. and on the opposite side of Lake Washington from the city. This conduit can then be extended around the northern end of Lake Washington to introduce a supply to the city from the north. In this manner water can be delivered to the distribution reservoirs from both directions. At the same time, all of the east shore of Lake Washington can be reached from the reservoir to which this conduit will deliver.

The Cedar River water supply system was projected and developed by Mr. R. H. Thomson, city engineer of Seattle, who was assisted by the late Mr. H. W. Scott, assistant city engineer. The construction of extensions to the supply system is under the direction of Mr. J. L. Stannard. Mr. L. B. Youngs is superintendent in charge of the operation and maintenance of the distribution system.

AUTOMATIC SEWAGE PUMPING by electrically driven centrifugal pumps has been adopted at Dayton, Ohio. The Great Miami river, on which the city is situated, is subject to heavy floods and levees have been built to protect the city from inundation. During high water, it is necessary to close the gates on the outfall sewers and to pump the sewage into the river. There are now three stations for the purpose, each fitted with pumps furnished by the Dayton Hydraulic Machinery Co. and with Westinghouse three-phase motors. The first station contains two 2,500-gal. pumps geared to 20-h.-p. motors, the second contains three 4,500-gal. pumps direct-connected to 40-h.-p. motors, and the third contains two similar units. At each station apparatus is provided for starting and stopping the units automatically when the sewage rises or falls below certain elevations in the pump chambers.

Electrification of Bavarian Railways.

The Bavarian Government is proposing to operate all of the state railways by electrical energy generated by water-power developments. The plans for this work were first made known a year ago in a general way, but recently a report has been published that discusses quite fully the investigations that have been made relative to the introduction of electric traction on these railways. This report states that the first installment of funds for the electrification of three lines near the Bavarian and Austrian frontier will be provided in the budget for 1908-'09. These lines are specially well adapted from the economic point of view to be operated with electric energy from hydro-electric developments, because they carry a very heavy traffic and have water-power in their immediate proximity, while coal is extremely expensive in the region traversed by them, owing to their distance from coal fields. Extensive investigations have been carried out as to the cost of working these lines electrically, as compared with the expense of steam traction. As a result of these investigations it is stated that electric traction on the projected frontier railways will be advantageous, as compared with operation by steam, and may even yield improved financial results. The cost of electrical energy was deter-

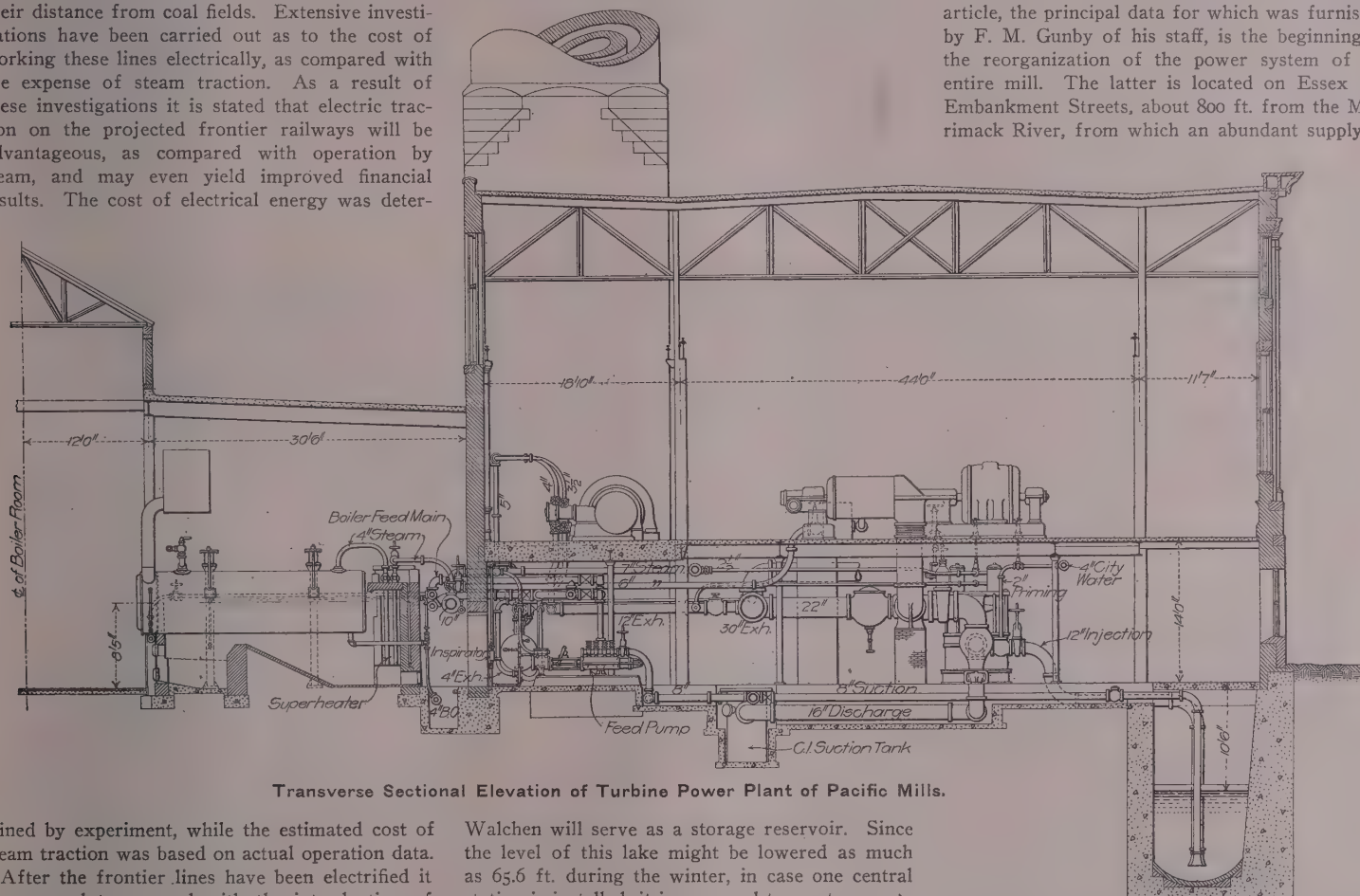
July, 1906, a month of maximum demand, amounted to 1,435,000 kilowatt-hours, to which 10 per cent. may be added for contingencies and for unavoidable irregularities. Adding all other losses, the mean requirements of energy at the turbines is estimated to be 142,000 hp. for that month. Making due allowance for an increase of traffic at the rate of increase from 1875 to 1907, it has been estimated that 202,000 hp. will be the mean requirement in 1920, while the maximum amount of energy required might reach 606,000 hp. From these estimates it has been assumed that the amount of water-power available is theoretically sufficient for all railway purposes.

Three principal power stations are under consideration, one at Bad Reichenhall, a second at Lechbruck and a third at Lake Walchen. The latter project involves the use of the falls between Walchen and Kochel Lakes, together with water from the Isar and Rissbach Rivers, while Lake

The Steam Turbine Power Plant of the Pacific Mills.

The Pacific Mills is one of the largest textile mills in the country, having a cotton department with 180,000 spinning spindles and 6,717 looms, a worsted department of 53,064 worsted spinning spindles, and 2,650 looms, and a print works with 27 printing machines. With the natural increase in the size of the plant, the increase of speeds of machinery requiring additional power, and the constantly increasing demand for steam for manufacturing purposes, it has become necessary to reorganize the entire power plant on a comprehensive basis. At present it consists of two sets of water wheels at the upper mill, one set at the lower mill, and several boiler plants and engines located in various departments.

The new power plant designed by Chas. T. Main, of Boston, and described in the following article, the principal data for which was furnished by F. M. Gunby of his staff, is the beginning of the reorganization of the power system of the entire mill. The latter is located on Essex and Embankment Streets, about 800 ft. from the Merrimack River, from which an abundant supply of



Transverse Sectional Elevation of Turbine Power Plant of Pacific Mills.

mined by experiment, while the estimated cost of steam traction was based on actual operation data.

After the frontier lines have been electrified it is proposed to proceed with the introduction of this system of traction on the railways running south from the capital toward the Alps. The first sections to be undertaken will be those from Munich to Garmisch and to Partenkirchen, and the railways to Tutzing, Peuzberg, Kochel, Weilheim and Peissenberg. Later the line from Munich to Bad Tölz and Schliersee, and the one from Holzkirchen to Rosenheim, and also the line in the vicinity of Munich to Gauting will come under consideration. In case of the railways in the north of Bavaria, which are less favorably situated as respects water-power and carry less traffic, it will only become possible to introduce electric traction at a considerably later date.

The amount of water-power available is so considerable that the conversion of only a part of it into electrical energy will suffice to provide the requisite power necessary to operate the state railways. A report issued by the government estimates the minimum amount of power capable of being supplied by various sources at 300,000 hp. To this must be added the much greater supply which could be obtained from lakes that might serve as storage reservoirs. The total daily output of energy required to operate the railways in

Walchen will serve as a storage reservoir. Since the level of this lake might be lowered as much as 65.6 ft. during the winter, in case one central station is installed, it is proposed to erect separate generating stations that it is believed will render possible the utilization of 50,000 available horsepower without damaging the appearance of the lake. This development will supply power to operate the railway from Munich to Garmisch and Partenkirchen. The works at Lechbruck will develop falls of the Lech River, rendering available 20,000 hp. from a main station and 1,300 hp. from a substation to operate a line from Garmisch to Griesen and one on the Austrian frontier. The works at Bad Reichenhall are intended to utilize the falls of the Saalach River above that city to furnish power for a local line.

The cost of the entire 50,000-hp. Lake Walchen project, including the works and generating equipment, is estimated at \$5,500,000. The development at Bad Reichenhall is estimated to cost about \$325,000, exclusive of electrical equipment. The cost of the Lechbruck works has not been stated, but, on account of the importance of these works and of those at Lake Walchen, it is proposed to institute an international competition for the designs, and a commission, consisting of German and foreign experts, will be invited to judge the plans submitted.

water for condensing and boiler feed is obtained, and beside the tracks of the Boston & Maine R. R., over which coal is received. The plant is intended to operate in connection with such portions of the present power system as will remain in commission temporarily or permanently.

The main building, consisting of the turbine room, 78 ft. 6 in. x 125 ft. 5 in., and a boiler room, 86 ft. 8 in. x 142 ft., is built with brick walls with granite and terra cotta trimmings, and concrete floors and roof. The framing is of steel throughout. The boiler room floor is on the same level as that of the turbine room basement and of the yard.

The turbine room floor is 14 ft. above the basement level, and this room is 25 ft. high under the roof trusses. Its floor is of reinforced stone-concrete, supported on steel beams. The turbine foundations and the floor are kept entirely separate in order to avoid any possibility of transmitting vibration from the machinery to the buildings. There are two rows of columns spaced 44 ft. centers on 17-ft. bays. In the space between these columns are located the main units. Between the west columns and wall is the switch-

board, and between the east columns and wall are the small engine units and exciters. The main generator space is covered by a 15-ton crane and the exciter space by a 5-ton crane, these cranes being hand-operated.

On the main turbine room floor are located three Allis-Chalmers turbine units of 2,250-kw. aggregate capacity on normal load, generating 60-cycle current at 2,300 volts; a 75-kw. engine-driven alternator capable of running in parallel with the above; a 50-kw. steam-driven, and a 55-kw. motor-driven exciter, and a 12-panel switchboard.

The turbines are designed to run at 1,800 r.p.m. Each is equipped with a centrifugal governor, and automatic overload and safety stop valves. The generators are of the revolving-field enclosed type, with forced ventilation. The air for this is sucked in by the rotating field through a duct leading to an air shaft, the opening for which is up near the roof, thus insuring a supply of clean, cool air. Each unit is supplied with oil by an oil pump mounted on its frame and direct-driven through gears. An auxiliary steam-driven pump supplies oil at starting.

In the basement are located the condensers, two

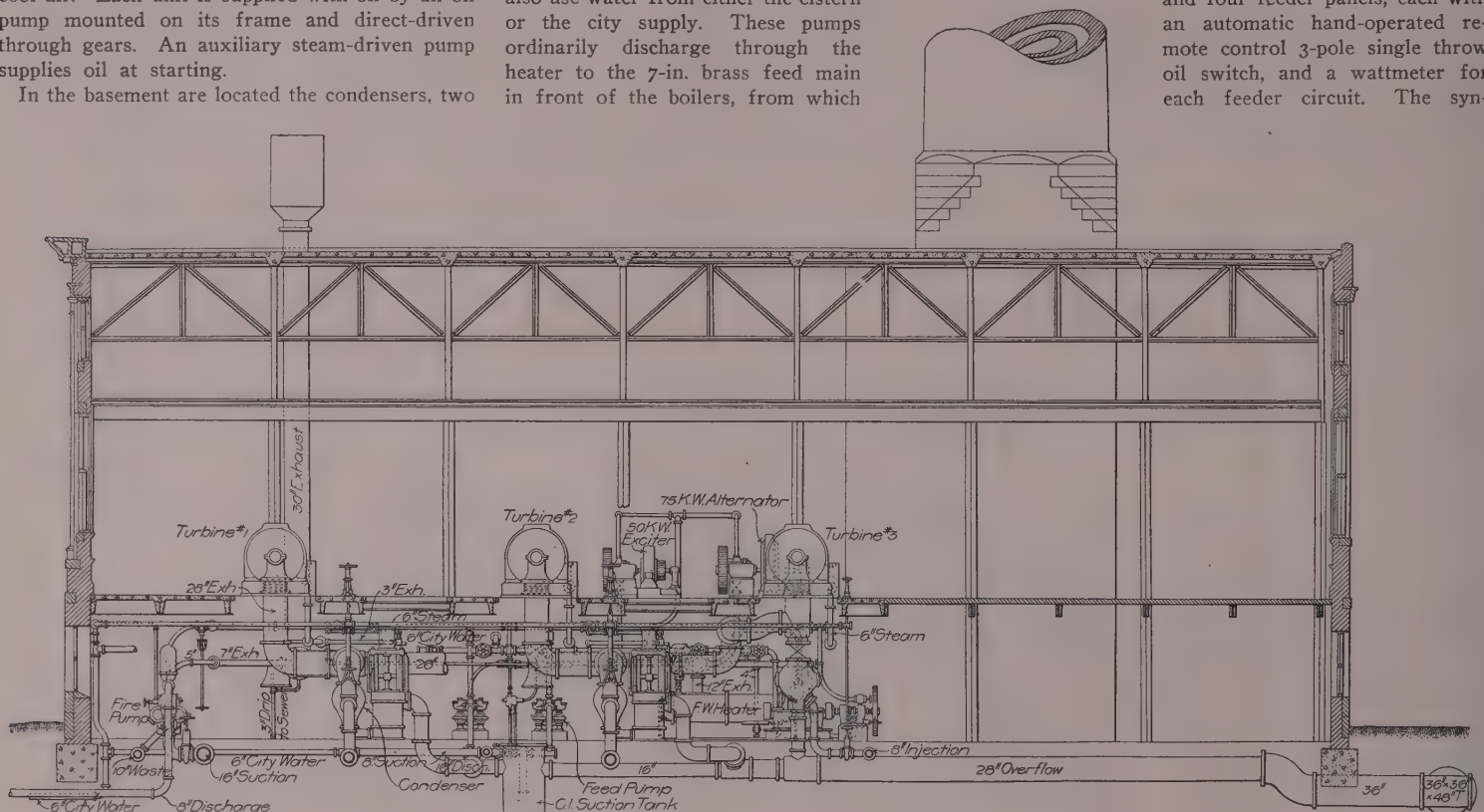
a Foster superheater. The steam pressure is 150 lb. per square inch, and the steam is to be superheated about 125 deg. Fahr.

After leaving the superheater the steam passes through a 4-in. nozzle with two valves and a bleeder into a 10-in. steel header, located in the boiler-room and below the level of the turbine floor. Two long bends between the superheater and this header, one vertical and one horizontal, provide for expansion. The header is divided into sections by by-passed valves, and is supported by balanced levers hung from the roof beams so as to make it as flexible as possible. Six-inch pipes feed the turbines direct from this header. Each turbine is provided with two valves, one at the steam chest and one at the header. The auxiliaries are fed from the header at two points. All piping is laid out to give the greatest possible allowance for expansion.

The feed pumps normally take water from the overflow pipe from the condensers, but they may also use water from either the cistern or the city supply. These pumps ordinarily discharge through the heater to the 7-in. brass feed main in front of the boilers, from which

The coal pocket is 209 ft. 6 in. x 52 ft. in plan. Coal is taken from this by a Whiting Foundry & Equipment Co. single-track trolley with a grab bucket. There are two lines of track for this in the coal pocket, one on each side of the trestle, the track being supported from the roof trusses. These two lines unite between the pocket and the entrance to the boiler room, so that a single line of track is carried down over the center of the firing floor inside of the latter.

The present switchboard consists of two panels for the direct-current side of the exciters, and one for the auto-starter for the motor side of one exciter; four panels for the alternating-current generators, each with one ammeter, one voltmeter, and one indicating and a recording wattmeter, a 3-pole single-throw non-automatic, hand-operated oil switch and necessary accessories, a total load panel with polyphase indicating wattmeter, Chapman voltage regulator, a power factor meter, and a 3-phase ground detector; and four feeder panels, each with an automatic hand-operated remote control 3-pole single throw oil switch, and a wattmeter for each feeder circuit. The syn-



Longitudinal Sectional Elevation of Turbine Room of Pacific Mills Power Plant.

12 x 8 x 14-in. feed pumps, two 1,000-gal. Underwriter fire pumps, and a 3,000-hp. closed feed-water heater. Two of the turbines are equipped with jet condensers, having twin double-acting steam-driven air pumps. The third unit has a turbo-jet condenser set built by Allis-Chalmers Co. This consists of a jet condenser mounted directly beneath the exhaust nozzle of the turbine. To this is connected a three-hole cycloidal pump driven by a small steam engine. All the condenser heads have adjustable spray cones. Openings are left in the floor above the condensing apparatus so that it can be reached by the large crane.

The present boiler installation consists of twelve horizontal return tubular boilers, built by the Bigelow Co., arranged in batteries of four each. Space has also been provided for twelve more boilers. Each boiler has 92 tubes, 3½ in. in diameter and 20 ft. long, and has an overhanging front. New England roller grates are used. The boilers are suspended by lugs and bolts from I-beams carried on columns independently of the settings. The latter are of red brick, lined throughout with fire brick. A steel flue with a damper regulator conveys the gasses to the chimney. Mounted in the rear of each boiler setting is

the boilers are fed. They may also be made to discharge into a cold-water feed main of iron, which is to be used in case of an accident to the main feed pipe, or for testing purposes. By operating the necessary valves, one battery or part of a battery may be fed in either manner. A Hancock inspirator has also been installed for night use, when the load will be extremely light. The high-pressure steam piping will be served by means of a No. 40 Holly drip system, and condensation will be removed from the low-pressure piping by means of traps.

The water is taken from the Merrimack River through a 48-in. steel penstock provided with sluice gate and screens, into a large concrete cistern located under the west side of the turbine room basement. The sides of this cistern form part of the building foundations and the bottom is low enough to insure an ample supply of water at all stages of the river. From this cistern the water is taken through the condensers and pumps, and is then returned to the river through another 48-in. steel penstock, which discharges further downstream. Provision has been made so that later, if it is thought desirable, warm water from the condensers can be carried over to the print works for use in manufacturing processes.

chroscope and exciter voltmeter are located on a swinging bracket at the exciter end of the board.

All oil switches are mounted on the wall back of the board, the operating levers being under the floor. The rheostats are on the basement floor. Machine and feeder leads are located on the basement ceiling. The feeder leads are taken to the north end of the turbine basement, where they are connected to the transmission cables by disconnecting switches.

The transmission system is entirely underground, thus avoiding the use of any lightning protection, and also providing against interference from future construction. The cables for the present installation are of two sizes, one circuit being of four 4-0 cables, one of three 3-0 cables, and one of two 3-0 cables. All cables are three-conductor, stranded copper, insulated with varnished cambric and protected by a lead sheath. The cables are insulated for a working pressure of 5,000 volts, but will operate, of course, at 2,300 volts.

The conduit system is made of multiple duct vitrified tile laid in concrete, with joints wrapped with burlap soaked in cement. This conduit is only two ducts wide throughout its length, so

that each duct has at least one surface exposed to the surrounding earth, thus avoiding a reduction in the carrying capacity of any cable, due to poor radiation. The manholes are generally about 300 ft. centers, with a maximum of 410-ft. centers. Racks are formed in the sides of these manholes by projecting courses of brick from the inside of the walls. The manholes are built with concrete bottoms, 8-in. brick sides, and concrete tops, carried on old rails, and have circular cast-iron covers.

The route of this conduit is such that it was necessary to cross the Boston & Maine R. R. tracks and a public street, at about the same point. In order to facilitate any future work at this point, a concrete tunnel was constructed here, with its top about 3 ft. below the surface of the street and road. The cables in this case are carried in racks formed by projections in the sides of the tunnel.

Some Recent Coking Plants.

By W. Archie Weldin, Construction Draftsman, The H. C. Frick Coke Co.

During the year 1907 the H. C. Frick Coke Co. constructed two new coking plants, named Collier and Phillips, in the Connellsville coke region of Pennsylvania and one, named Dearth, in the Lower Connellsville region. The coal shipping plant at Ronco mine, situated on the Monongahela River, in Fayette County, has also been converted into a coking plant, and a new shaft, for ventilation and drainage (and later for hoisting coal) was sunk in the field of coal being mined by the Standard Mine, situated in Westmoreland County. These are among the most recently constructed plants in this region and involve various unusual features.

Ovens.—All the ovens are of the beehive type, 12.5 ft. in diameter. They were built from the company's standard plans, which have been drawn

thick part of the wedge, is withdrawn by reversing the ram. The pinion driving the ram is mounted on a vertical shaft, about which the ram may be swung in a horizontal plane.

The machine is first set directly in front of the oven. When the coke in the center of the oven has been drawn the machine is set first to one side and then to the other. In this manner about 90 per cent. of the coke in the oven is drawn by the machine. The remainder is drawn out by hand.

The conveyor is in two parts. One part runs horizontally parallel to the ovens and extends from the last oven drawn, where it receives the hand-drawn "gleanings," under the extractor ram, where it receives the coke drawn by the machine. Beyond this it rises slightly and delivers the coke to the second part, which runs across the yard at right angles to the first part. This conveyor is inclined, being balanced with a counterweight on the end of a wire rope rove through pulleys on a small tower on the machine. This conveyor can be adjusted in height to load various cars, which it does over the end of the conveyor through a suspended "basket" which breaks the fall.

Both conveyors are made of steel plates riveted to two chains and carry the coke on their top strands. The inclined conveyor has small openings between the plates, which serve to screen the coke. The entire machine is carried on two trucks forming a rigid wheel base of about 23 ft.

The machine draws about 40 ovens per day. It requires two operators, as men cannot stand the heat and labor of swinging the ram for long periods at a time.

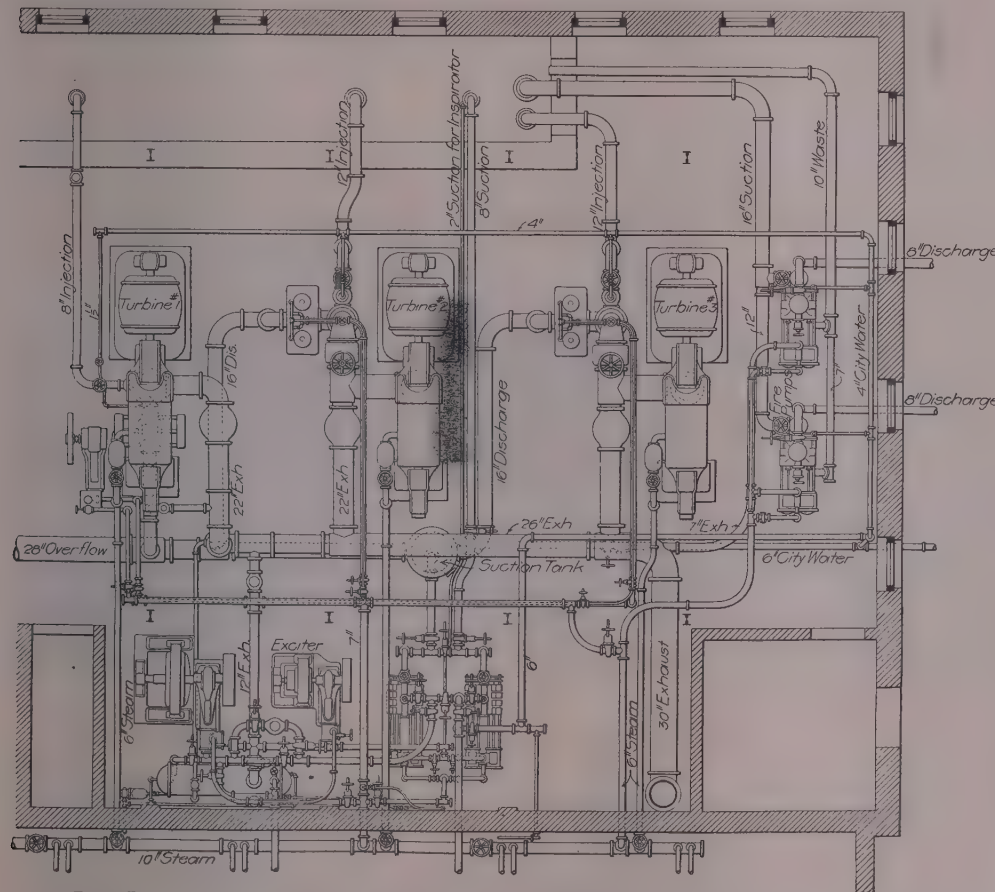
The economy of machine drawing is great. The direct saving in labor is large, and the saving in time is also important, because of the reduced cooling of the ovens during drawing and the consequent quicker starting of the coking process in the next charge. Besides the economy of machine over hand labor, the introduction of machines has been of great advantage from the fact that it has of late become more and more difficult to obtain a supply of men to do this heavy work.

It is said that the results of recent tests show that, considering all charges of maintenance, interest, depreciation and so forth, the cost of drawing coke by machine is less than half the cost of hand drawing. There is also considerable saving in the first cost of a plant designed for machines over one arranged in the usual manner.

Masonry retaining walls, 8 or 10 ft. high, are usually built along both sides of the depressed shipping tracks, the cars being loaded with wheelbarrows from the top of these walls. These walls are dispensed with entirely, as the machines elevate the coke. Another result of this arrangement is a reduction of 6 or 8 ft. in the vertical distance from the top of rail of the yard track to top of rail of the larry track on top of the ovens. As the elevation of the yard or shipping track is generally fixed by considerations of high water or railroad connections, the larry track is usually required to be carried on a trestle from the bin to the ovens, and many of the ovens must be built high above the natural surface of the ground on dry masonry. As the larrys must run under the bin, the height of the latter also depends on the height of the larry track. The machine plant, therefore, is cheaper than the plant for hand drawing by the cost of these retaining walls, oven masonry, height of larry trestle and height of tipple.

Where the topography is such that the oven foundations can be placed to best advantage slightly below the natural surface of ground the yard tracks are in excavation, and the retaining walls are still required in the hand-operated plant. In the machine plant all this excavation and these walls are saved.

To offset these savings there is the cost of the



Part Plan of Turbine Room, Showing Equipment Installed, Pacific Mills Power Plant.

At the outset the power generated at the new plant will be used principally to supply what is known as the upper mill and print works; but provision is being made for the extensive application of electric motor drive throughout the entire establishment, divided about as follows: Yarn mill, 1,500 h. p.; upper mill, 3,000 h. p.; lower mill, 3,000 h. p.

AN INTERESTING ENGINE EQUIPMENT has been installed in the new lake steamer, the City of Cleveland, of the Detroit & Cleveland Steamboat Co., consisting of an inclined three-cylinder, compound engine, with 54 and 82 in. by 8-ft. cylinders, the high-pressure cylinder being in the middle. A special valve gear is used that gives each cylinder a wide range of expansion, the cut-off of each being adjustable from one-quarter to five-eighths stroke, by means of levers on the starting platform, and this is utilized for the purpose of dividing the power of the engine equally between the three cylinders. In the trial trip, which was held recently, the engine developed 6,600 i.h.p. at a speed of 30 r.p.m., using steam at a pressure of 160 lb.

with especial reference to drawing the coke with machines. The principal variations from the ordinary oven are that the door has been made larger; the jambs have been given a greater radius; the lower jamb has been made of cast iron, and the cast iron doorsill has been made to project 8 in. beyond the oven wall. The object of these changes is to allow, respectively, the machine to draw a greater proportion of the charge, to reduce the wear on the jambs and to insure the coke falling well into the conveyor of the machine.

Coke Drawing Machines.—The coke is drawn from the ovens and loaded on the cars by a machine manufactured by the Covington Machine Co., of Covington, W. Va. This machine consists of two principal parts, the extractor and the conveyor. Both these parts are actuated by electric motors through gearing. The machine is also moved along its track from oven to oven by a motor mounted on it. The extractor consists of a ram carrying a rack on its side. On the end of this ram is fixed a cast iron head semi-circular in plan and wedge shaped in section. This head is forced under the coke, which, falling behind the

track for the machine, the machine itself, the turn and transfer tables and so forth. But in the tests cited above the machines were installed at a plant having walls and so forth, so that the saving in construction mentioned would reduce the charges for interest made in said tests and increase the saving shown.

Transfer Tables.—In order to have the benefit of interchangeability in case of breakdown, transfer tables were installed. The ovens are arranged at the different plants in from three to seven rows. In front of each row is the track for the machine, one machine being provided for each row and the number of ovens in a row being enough to provide a day's work for the machine. The transfer table at each plant runs on two standard-gauge tracks across the ends of the rows of ovens. The arrangement is such that any machine can quickly be transferred to any track.

Each table consists of a structural steel frame carrying the machine track and mounted on four pairs of standard M. C. B. wheels. The axles are fitted with roller bearings in boxes especially de-

The steel used in the coal tipples, particularly at the coking plants, is especially liable to corrosion. The shafts under the headframes are usually "upcasts," or the final outlets of the mine ventilating systems. The air coming up these shafts is generally warmer than the outside air and is laden with all the diluted gases from the mine, products of combustion from explosives, and so forth. In cold weather this rising column of air is a regular fog of condensing vapors, which deposits moisture and perhaps some acids directly upon the steelwork. Then, too, although the tipples are carefully located as far away from the ovens as possible and as much as possible out of the prevailing path of the smoke, the steel is unavoidably attacked by the sulphurous fumes from the coke ovens. Particularly is this true, as the water condensed on the steel, as already explained, dissolves the sulphur dioxide (SO_2) in the smoke, forming sulphurous acid (H_2SO_3), $SO_2 + H_2O = H_2SO_3$.

Experience has shown that after about 15 years' use tipples in this region have to be extensively repaired almost every year, and some have been

specimens will be made of all steel structures, and when necessary the steel work will be thoroughly cleaned with sand blast machines and an approved brand of paint applied immediately.

Collier and Phillips Plants.—At these plants the mine openings are shafts. The headframes are 107 ft. high to the sheave platforms. Self-dumping cages deliver the coal through gravity distributing chutes to bins of 800 tons capacity. The coal, being all used in coking at the plant, is not screened or weighed; but a man is required at the tipping point to collect the miners' checks from the mine cars. The headframes consist of two vertical bents and one inclined bent or "main brace." Each bent has three columns, the outer ones having a batter of 1 in. to the foot. The main brace is placed at an angle of 30 deg. with the vertical. The columns are all of the 6-in. Z-bar type, $\frac{3}{8}$ in. metal, braced with double-built channel struts and stiff angle diagonals. The halves of these double struts and diagonals are connected together with batten plates.

The diameter of the head sheaves is such that the resultant load is equal on the two vertical



Two Construction Views of Typical Steel Structures of the H. C. Frick Company.

signed for this purpose. The transfer tracks cross the yard tracks at grade with standard frog crossings, the machine tracks extending beyond the ovens a sufficient distance to gain the small elevation required. Latches are provided to secure the table in exact position while moving the machine, and cast iron movable steps prevent over-running.

Turntables.—Turntables were installed to turn the machines. This is often required, as in case a machine from one side of a double block of ovens is to be moved to the opposite side or facing the opposite direction. The turntables have a structural-steel frame, and the weight is carried on four cast iron rollers running on a single circular rail. These rollers are placed at the corners of a rectangle of such size that it always contains the center of gravity of the machine whichever truck comes on first. The rail on which the rollers run is spiked to short ties resting on a circular concrete wall. At the center a concrete pier carries a casting having a vertical pin. This pin projects through a similar casting on the table and forms the center of rotation. The turntables are placed close to the transfer table so as to serve most conveniently all the trucks.

The tables were fabricated and erected by the force of the company's structural and repair shop at Everson, Pa.

Tipples and Bins.—All the tipples and bins are of structural steel. They were designed by the company's engineers and, except as mentioned below, were fabricated and erected by the American Bridge Co.

found considerably corroded in places after a much shorter term of service. The tipples which have been recently repaired were generally made up largely of metal $\frac{1}{4}$ in. thick. Latticed channel columns were also generally used, and small channels and beams having very thin webs were frequently employed. Adjustable rods were often used for tension members, and the whole design of practically all tipples in this region constructed several years ago is very much lighter than is now considered good practice.

The tipples about to be described were carefully designed to secure longer life than has been obtained heretofore. No metal of less thickness than $\frac{3}{8}$ in. is used in principal members, and the use of metal of less than this thickness elsewhere (as in channel webs) is avoided as much as possible. No latticing is used at all, and all details are carefully designed to facilitate thorough painting. All sections of members carrying principal stresses are slightly increased to allow for corrosion. The cost of this extra metal is, of course, a much smaller part of the total cost than the ratio of the extra weight to the total weight, as the cost of fabrication and erection is not proportionately increased. The expense of replacing unsafe members, which is always done as far as possible without shutting down the plant, is much greater per unit of weight than the original cost of those members, so that the economy of a relatively heavy design is evident.

In order to secure the full advantage of these features of the design, and to preserve existing structures as far as possible, regular annual in-

spections will be made of all steel structures, and when necessary the steel work will be thoroughly cleaned with sand blast machines and an approved brand of paint applied immediately.

The bins are of the self-emptying type of original design. It has been found by actual measurement at existing plants where flat bottoms are used that only 40 per cent. to 60 per cent. of the capacity of the bin can be drawn through the gates without expensive shoveling. It is estimated that 97 per cent. can be withdrawn from this type of bin under normal conditions. This increased available storage has a very material effect upon the smooth operation of the plant.

The bottoms of these bins are composed of $\frac{3}{8}$ -in. steel plates on longitudinal I-beams. These are supported on girders of an inverted V-shape, having their ends tied together. Each of these girders rests on two masonry piers.

The bins discharge through vertical gates in

the sides, which gates are raised by rack and pinion and chain wheel. Chutes fixed to the bin direct the coal into the motor-driven laries which run over the ovens.

Dearth.—The tippie at Dearth Mine is designed to be operated in connection with a chainhaul, which delivers the loaded mine cars up a 27 per cent. incline approach to the top of the bin. The cars are dumped on two Phillips patent crossover dumps placed tandem. From the last dump a "kickback" and spring switch serve to deliver the cars by gravity over the empty track to the foot of the approach. The two tracks are parallel and 8 ft. apart. The bin is 20 ft. wide, so that the center of the load track is 2 ft. from the center of the bin. This arrangement allows the bin to be filled fairly well without chutes or conveyors. This bin has a capacity of 500 tons, and the bottom is flat. There being only 250 ovens at this plant instead of 400, as at the other plants, the storage capacity of the bin required is not so great. The sides of the bin are steel buckle plates riveted to vertical beams, as at Collier and Phillips, but the bottom is formed of 3-in. plank. As

coal consumed at this shaft. Later, when the workings have been further developed, a large bin is contemplated. The coal will then be hauled over land by larry trains to the present ovens. It is expected that this will be more economical than underground haulage for the part of the mine served by this shaft at that stage of development.

Larry Trestles.—At Ronco plant two of the larry tracks are carried over the yard tracks on steel trestles. They are composed of I-beam deck spans on I-beam posts braced with angles. They were fabricated and erected by the force of the company's shops.

Power Plants.—At all the plants the oven laries and the coke-drawing machines; at Dearth, the chain haul and the mine haulage, and at Ronco, the picking bands and conveyors are operated by electricity generated at the plant. An exception is Collier, where the current is obtained from the company's central plant at York Run. This power is transmitted by a three-phase, high-tension line to a substation at the plant, containing two 200-kw. rotary convertors. There is,

will instantaneously shut off steam to both engines. These valves open under steam pressure and are normally wide open.

At Standard No. 3 the fan is of the same type, but is 26 ft. diameter and 7 ft. wide. It is driven by twin 22x24-in. engines.

At Dearth there are two fans, one for each of the two slope openings; one 16 and one 20-ft. diameter reversing fans, direct driven by 12x20-in. and 16x24-in. engines.

Boiler Plants.—The boiler plants at Phillips and Standard consist of three water-tube boilers of 300 h.p. each. At Collier the three boilers are of 250 h.p. each. At both plants the boilers are connected with a brick stack, 150 ft. high, with steel breaching. Feed water is heated by exhaust from engines. Steam is maintained at a pressure of 125 lb.

At Dearth two boilers of 250 h.p. each are separately connected to two steel stacks, 80 ft. high.

Waste Heat Systems.—The boilers are fired with the hot gases from certain of the ovens. The boiler settings are only slightly modified to effect this, and the boilers can readily be fired with coal without interfering with the operation of the flue system. A switch is arranged so that coal can be delivered to the boiler house by larry in case the waste heat system is partially or wholly out of commission.

The hot gases enter the boiler back of the grate bars through a firebrick flue of rectangular cross-sections, running under all the boilers parallel to the fronts. This flue is 17 in. wide, 6 ft. 6 in. high, and runs the full length of the boiler house, just under the floor, extending about 15 ft. beyond the building at each end. Under the boilers the arched top of the flue is omitted so that the gases rise in a vertical sheet up through the tubes.

A slot through the floor and the top of the flue is formed beside each boiler. This opening is usually covered with tile, but is intended to receive a water-cooled damper suspended from a convenient chain block. This damper is inserted to shut off the boiler for cleaning and other purposes. This rectangular or boiler-house flue is fed from the main flue along the ovens through branches joining the two at right angles. These branches, the main flue, and the small flues connecting each oven to the main flue are all of inverted U-section. The side walls are composed of two courses of firebrick inside and one of common brick outside. They rest on dry masonry footings extending down to suitable bed. The bottom of the flue is paved with firebrick on edge resting on clay tamped between the footings. The top is a full-centered arch of two layers of firebrick and one of common, resting on the side walls. Expansion is provided for by omitting the fire clay mortar between the ends of the bricks, thus distributing the motion throughout the length of the flue. This is believed to be much better than concentrating the motion at a few points where it assumes considerable magnitude and is difficult to manage. A water-cooled damper is provided for each branch flue.

The main flue is buried in the ground back of the bank ovens and is parallel to the ovens in line and grade. The size of the main flue is increased at every fifth oven, beginning at the ends farthest from the boiler house, the largest sections being at the center. At the points where the section changes the top of the intrados is kept in line, the offset being at the sides and bottom. Each oven is connected to the main flue by a feeder flue, 18 in. high, which is connected to the crown of the oven with a built ring near the top. Only a part of the row of bank ovens is connected to the system. It is calculated that each oven furnishes from 15 to 18 h.p., and enough ovens are connected to furnish the power for which the plant is designed. A plate damper can be in-



A Waste-Heat Power House in Connection with a Coke Oven Plant.

the bin had to be placed close to the ovens, the larry track could not be laid on the ground; so it is carried on a floor system supported by the main bin columns. Batter columns extend from the bottom of the bin to the ground. These are necessary to relieve the main columns of the bending due to wind load.

The haul is operated by an electric motor placed in a machinery room under the "knuckle." Several sprocket wheels with patent safety pawls are arranged along the length of the approach so as to prevent the cars from rushing to the foot in case the chain should break.

Ronco Mine.—At Ronco Mine the work consists of the addition of 17 ft. in height to the existing headframe; the placing of batter columns to care for the increased wind load; the installation of shaking screens, picking bands, crusher and conveyors; and the building of a large bin similar to those built at Collier and Phillips. The extensions to the tippie were fabricated and erected by the force of Everson shops of the H. C. Frick Coke Co. and the bin by the American Bridge Co. The Ronco plant has been in operation for some years as a coal shipping plant. Coking coal has been shipped to certain by-product works of the U. S. Steel Corporation. The present addition is designed to operate in connection with this business. Coal can be shipped screened, picked or crushed, or any combination of these, or coked after screening and picking.

Standard Mine.—The No. 3 shaft at Standard Mine has been put down primarily for purposes of ventilation. A headframe built from the same plans as those at Collier and Phillips has been erected, however, and will be used to hoist the

however, a steam engine, as at the other shaft plants, to operate the hoist and the fan, steam being considered more reliable where continuous operation is imperative. At Phillips the electric current is generated by two 100-kw. generators direct connected to two 14x14-in. high-speed, four-valve, automatic engines. At Dearth 200-kw. generators are direct connected to two 18x21-in. engines of the same type.

Hoisting Plants.—At Phillips 24x48-in. and at Collier 24x36-in. engines are used to hoist the coal up the shafts. These engines are equipped with balanced valves, steam brake and reverse, and an automatic device to prevent overwinding.

The steam line to the hoist at Phillips is over 800 ft. long, as the utilization of the waste heat from the ovens necessitates placing the boiler house near the center of the bank ovens. The line feeds a large receiver separator placed close to the engines and is carried on roller supports. Expansion is taken care of in one swivel swing joint near the middle of the line, the pipe being securely anchored at each end.

Fans.—The mine ventilating fans at Phillips and Collier are 20 ft. in diameter and 8 ft. wide. They have half steel housings and are reversible, though normally operated as blowers. Two 16x24-in. engines, one at each end of the fan shaft, drive each fan. By means of plate couplings either engine may be temporarily disconnected. The steam supply of these engines is controlled by special steam-operated globe valves, one in each engine house and as near the engine throttle valve as possible. These special valves are connected by small piping in such a manner that opening a small valve or cock in either fanhouse

serted in the feeder flue to exclude the cold air when the oven is open while coke is being drawn.

The general design of these flues is the result of the experience of the company at several of its plants. It has been found at these plants that the cost of maintenance of the flues is unexpectedly high, and the present design is expected to reduce this charge. The whole flue system is practically a combustion chamber, and the temperatures in the flues are very high.

Mine Buildings.—The mine buildings at the various plants have been made as nearly uniform as possible. The repair shop, boiler, engine and power houses are built of common, hard-burned brick laid in lime mortar tempered with cement. The roofs are all supported on steel Fink trusses designed to carry calculated concentrated loads on the lower chord, representing shafting, steam lines, and so forth, and in the engine house the hoisting drums. The latter provision is believed to be of considerable economy, owing to the difficulty in repair work of blocking up the drums and other parts of the hoisting apparatus, and the consequent loss due to longer shutting down of the plant during such repairs. The roofs are all covered with No. 1 ribbon Bangor slates nailed with copper nails and flashed with 16-oz. copper.

Boiler Houses.—The boiler houses have doors at each end large enough to admit a car for the removal of ashes produced from the occasional use of coal. A glazed door, forming part of a triple window effect, is opened to allow the larry to chute coal to the floor, the front wall of the house being proportioned as a retaining wall, carrying the fill, on which the larry track is laid 5 ft. above the boiler house floor. The floors are of 12x12x3-in. clay oven tile, laid on a 6-in. foundation of fine coke ash, the joints being grouted with cement mortar. The interiors are given two coats of white cold-water paint, which adds greatly to their appearance and improves the light.

Power Houses.—The power houses are similar to the boiler houses, except that the appearance of the interior is improved by making the roof sheathing of beaded yellow pine, nailed to yellow pine rafters, surfaced four sides, which are dapped over yellow pine stop chamfered purlines. All of this woodwork is treated with a good coat of grain alcohol shellac and one of Murphy's No. 1 spar varnish.

Repair Shops.—The repair shops are located close to the mine openings so as to be convenient for repairing mine cars, motors, tools and the like. The shops are each provided with a brick and concrete wheel pit, drill presses, fans and other apparatus, all of which is driven by motors hung from the roof trusses.

Stables.—The stables are of wood construction and are of two sizes. One accommodates twenty head of stock, the other thirty. They also contain box stalls, harness rooms and similar divisions. Instead of using wooden floors, as is generally the custom in the coke region, the floors are made of tile and brick, laid in the same manner as in the boiler houses. The stall floors are graded toward the backs, where they are drained by concrete gutters. As the tile is too hard for the stock to stand upon continuously, each stall has a top floor of 2x2-in. W. O. slats spaced $\frac{3}{4}$ in. apart. These can be removed for cleaning. So far this floor has proven very satisfactory. It is also more sanitary than a wooden floor, since it is easily cleaned.

The second stories are used for storing feed and supplies. Hay tracks extend from end to end, and bins of three carloads' capacity are provided for oats. The stables are framed entirely of white oak, sided with yellow pine and roofed with slate. Each is provided with a detached saddlery shop, where harness repairs are made.

A corn crib of 1½ carloads' capacity and a wagon shed large enough to shelter the wagons

and carts in use at the plants are near the stable.

Tenements.—There are four different classes of tenement houses at each of these plants. The lowest in the scale are double houses of four rooms to the side, 28 ft. front by 30 ft. deep, with front porches, 6x28 ft., and two rear porches per house, 6 ft. square. The stairs to the second story are in the kitchen and are not enclosed in the room above. The kitchen has a closet under the stairs. The houses in the next class are double houses of four rooms to the side, 32x30 ft., with porches the same size as the last described. The stairs are enclosed between the front and rear rooms, thus making each room private. Each room has a closet, a rather unusual feature in this class of tenements. The houses of the next class are exactly like those just described, with a kitchen addition in the rear. The highest class of dwellings consists of single houses of six rooms and bath each. They are provided with kitchen sinks, hot and cold water, electric light, spacious porches, cellars and similar conveniences.

The superintendents' houses are of nine rooms each, consisting of reception hall, parlor and dining room and kitchen on the first floor, and four bedrooms and bath on second floor. Each room has a spacious closet. The house is heated by a hot-air furnace and lighted by electricity.

All the houses are built on stone foundations, have hemlock framing, slate roofs and all except the last two mentioned, have yellow pine siding. They are all plastered with Colonial wall plaster, with a hard skim. They have yellow pine floors, bases, trim, chair rail and other trim. All woodwork usually painted is given three coats of white lead and linseed oil paint. The hearths are of concrete instead of the usual rough brick. All window and door openings are provided with weather strips. The last two houses mentioned above are sided with white pine and finished inside with "clear" yellow pine. The outside has three coats of paint, as above, the body being French gray, the trimmings cream white.

Water Systems.—Water is used to quench the coke in the ovens, about 1,000 gal. being required per oven per day. This is applied by hand, with a hose attached to a special "coke oven" valve on a 1-in. pipe riser at every second oven. These risers connect to a 4-in. main under the yard in front of the ovens, which draws its supply from a main line coming from a reservoir located on high ground nearby. These reservoirs are steel plate tanks of 500,000 capacity each at Collier, Phillips and Ronco, and 300,000 gal. at Dearth.

Outside hydrants are provided for the tenements. Water is also delivered to the two better classes of dwellings mentioned above; to the stables, the boiler houses and other buildings and to a system of fire plugs. In the stables connected hose reels are provided, and at a convenient point hose reels on wheels are stationed in small buildings erected for the purpose. Hose drying towers are also provided.

These plants have been designed under the immediate supervision of Mr. W. R. Elliott, construction engineer, and the buildings were designed by Mr. H. C. Frank, architect for the H. C. Frick Coke Company.

THE WATER SUPPLY of Rio de Janeiro, Brazil, is being increased from a present capacity of approximately 38,300,000 gal. a day to substantially 53,550,000 gal. a day by extensive improvements involving an expenditure of nearly \$9,000,000. Rio de Janeiro is in a district similar to the District of Columbia, and the water supply is provided by the Federal Government. The present works include eleven separate stations, in the hills near the city. The additional supply is also to be obtained from these hills, which are controlled by the Government and insure a large quantity of water quite satisfactory for domestic purposes.

Operating Results of the Water Purification Plant at Ithaca, N. Y.

By E. M. Chamot, Ph. D., Asst. Professor of Sanitary Chemistry and Toxicology, Cornell University.

Continued requests for information relative to the results and operation of the mechanical filters installed at Ithaca, N. Y., as a result of the typhoid epidemic of 1903, have been made on the authorities in charge of the plant, but a combination of circumstances has heretofore prevented the publication of any data. Soon after placing the purification plant in service, the city of Ithaca acquired the entire water-works system under condemnation proceedings, following a vote for municipal ownership. During the litigation of many months which followed it was impossible to edit the data which had been collected. In the meantime the city had been developing a ground-water supply, on which work was first begun immediately following the typhoid epidemic. Before the hearing was closed the municipality found it possible to abandon the filters and supply ground water to all consumers. Moreover, part of the record books and all of the copies of reports were placed in evidence, and when the hearing closed, the return of these papers being refused and the filters being no longer in service, the task of recalculating all the results from the meagre data in note books seemed so discouragingly great that all thought of publication was abandoned. Persistent demands, however, from engineers and water analysts for data soon showed that it was necessary to attempt the recalculation of the lost data. As a further incentive the ground-water supply has proved inadequate and it has been found necessary to again place the filter plant in service. The data therefore no longer deals with an abandoned system, but one in actual service at the time of writing.

An extended account of the construction, with plans, of the Ithaca water purification plant appeared in The Engineering Record of Aug. 29, 1903, to which the reader is referred for details. The present article deals merely with the results obtained, and only a very brief résumé of the arrangement of the plant is therefore necessary.

The source of the water is a small stream locally known as Six Mile Creek, having a catchment area of about 50 square miles, with a population of about 40 persons per square mile. An impounding reservoir has been formed in the stream by a 30-ft. reinforced concrete dam constructed a little over a mile from the purification plant at a point where the stream bed forms a narrow gorge through the rocks. This dam backs up the water into an amphitheater, forming a pond of some twenty acres with a capacity of 72,000,000 gal. From the bottom of this reservoir the water flows through a 24-in. line to the pump house, whence it is raised by steam or water power to the purification plant through a 20-in. pipe.

The purification plant is the design of Mr. Allen Hazen, with the co-operation of Prof. Gardner S. Williams and the New York Continental Jewell Filtration Co. It consists of two coagulation basins arranged in parallel, each of 218,500 gal. capacity, when filled to the normal height for use; six rapid-sand filters of 500,000 gal. each and a pure-water basin of 500,000 gal. capacity.

The coagulant is dissolved in two tanks each holding 1,700 gal., whence it is raised to a small distributing or orifice tank through hard-rubber pipes by bronze centrifugal pumps run by Pelton water motors, the shafts of motors and pumps being coupled. The distributing tank consists of two sections, each with a separate discharge orifice; weirs at the center allow the excess of coagulant solution to flow back into the solution tank from which it is being pumped and at the same time maintain a constant head upon the discharge orifices. These orifices consist of hard-

rubber plates with semi-circular slots, over the top of which play hard rubber disks, fastened to a vertical spindle provided with a graduated head. The coagulant is introduced into the raw water just after it enters the filter house; thus treated, the water flows through a vertical pipe provided with a sharp-edged circular weir 20-in. in diameter, set in the hub of the pipe. A horizontal 1-in. pipe is tapped into the vertical 20-in. pipe and is attached to a glass water-level gauge provided with a scale whose zero point is at the same elevation as the edge of the weir, thus enabling the filter attendants to learn the rate of pumping. The weir discharges into a mixing tank through a series of five baffles, and from the mixing tank the water passes into the coagulation basins through large gates. In the basins the water takes the course indicated by the arrows in the accompanying drawing, passing around the baffles and eventually reaching the influent tank in the filter house, whence it flows to the filters.

Coagulation Basins.—The coagulation basins are of reinforced concrete, covered and placed completely underground. Board baffles, arranged as shown in the illustration, serve to retard the flow of the coagulated water and to increase the deposition of sediment and sludge. As the result of many tests it was found best to always use simultaneously both basins, thus prolonging the period of coagulation. The average time in hours

lation basins is very large. It has reached as high as 35 tons per twenty-four hours, calculated from determinations of the total solids in suspension in the raw water.

By far the greatest quantity of sediment is deposited near the entrance to the basins, in the sections marked Sections A and B in the drawing. If we call the quantity of sediment deposited at the outlet of the basins, where they discharge into the influent tank, one, then the quantity of sediment deposited in Section B appears to be at least six to ten times as great. This estimate is based upon measurements taken each time the basins were cleaned. Because of the relatively greater deposition in Section B, the experiment was tried of still further slowing down the flow of the water by placing a weir between piers in the south basin as shown by the dotted line in the figure. The two basins were run thus for many months and the results compared, but the increase in the amount of sludge deposited was so slight as to be practically negligible.

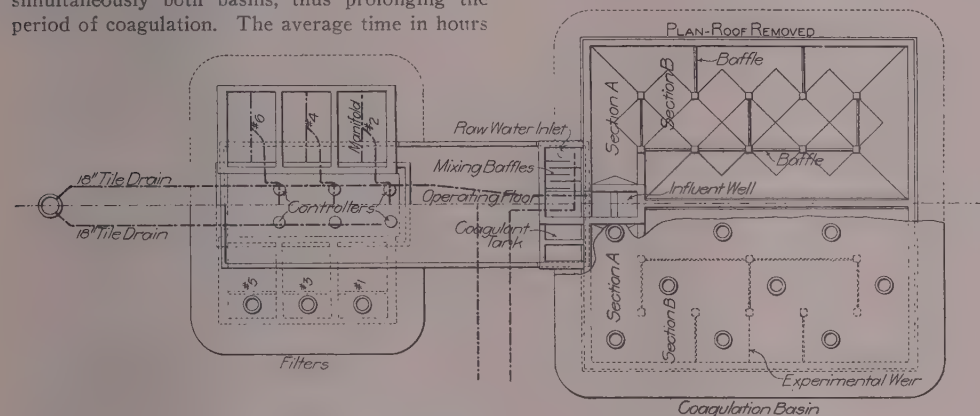
The monthly averages of the bacteria per cubic centimeter remaining in the water after subsidence are given in Table 1. The high counts of January, March and May show the result of running the basins without monthly cleaning. That the efficiency of the basins may be made very

ranging from 2,500 to 4,500. If these few exceptionally high quantities are excluded in the averaging it is found that the average amount of coagulant used is approximately 1.3 gr. per gallon. Rates as low as the minimum, 0.5 grain per gallon, could never be maintained for more than a few hours at a time.

The coagulant employed has always been basic aluminum sulphate, "Filter Alum," having an average content of about 17 per cent. of water soluble alumina. The coagulant solution is prepared by placing a weighed quantity in a loose-bottomed box at the top of the rectangular, concrete dissolving tanks, allowing filtered water to slowly flow through until the tank is filled and the undissolved "alum" completely submerged. A current of compressed air forced into one corner of the tank assures complete mixing. When the plant was first placed in commission solutions of definite percentage strengths were employed, and this system was adhered to, the amount of coagulant added in grains per gallon being calculated from curves, plotted for the number of filters in service. Under normal conditions the coagulant was made so as to contain 3 per cent. of the filter alum as weighed out; but during periods of high turbidity solutions of 6 per cent. were employed. In order to learn if possible the most convenient and effective strength, under the conditions which obtained at this plant, runs were made at different seasons and under variable conditions with solution strengths of 1, 2, 3, 4, 6, 8 and 10 per cent. The most satisfactory results appeared to follow the use of solutions of 3 per cent. This strength was therefore adopted by the writer in all of the subsequent working of the plant. When dealing with high turbidities, however, the necessity of applying large quantities of coagulant caused such a rapid consumption of the coagulant solution that a tank would be emptied before a fresh supply could be prepared. It was necessary therefore to make use of much stronger solutions, usually 5 per cent. or 6 per cent. As soon, however, as the turbidity began to fall, the solutions in the tanks were again diluted to 3 per cent.

The power of the coagulant to rapidly clarify the water and yield a satisfactory filter influent seemed to be dependent at times on the character of the precipitate of aluminum hydroxide formed. During very cold weather and moderately clear water, the decomposition of the aluminum sulphate was very slow, the resulting precipitate separated in very fine flocs, and refused to agglutinate and settle in the basins, thus throwing more work upon the filters and causing more frequent washing and an increased percentage waste through wash water. In no case was this change due to a deficiency of alkalinity, nor was it possible to cause any appreciable change by the application of lime, soda ash or ammoniacal liquors, but the introduction of muddy water (obtained by stirring clay in water) to the raw water just after the application of the coagulant would almost invariably start agglutination of the particles, this once started curiously enough would rapidly spread throughout the entire coagulation basin. Rarely this phenomenon of the change, from a slowly subsiding very finely divided precipitate to a large, flocculent, rapidly subsiding one, would start spontaneously. In practice, as soon as the fine difficulty handled precipitate appeared, the filters were thrown out of commission, the influent run to waste and a few parts of muddy water added; the reaction once properly started, the plant was placed in service under normal conditions. Another interesting fact which is probably pure chance is that our records show that the best coagulation took place when the raw water stood at about 8° Cent.

Some difficulty was at first experienced in properly checking the accuracy and care of the filter house attendants in the making up of the coagulant of proper percentage strength. It is, of



General Plan of Ithaca Filtration Plant.

that the coagulated water remained in the basins before reaching the filters will be found in the fourth column of Table 1. The period could of course be varied by changing the number of filters in service or by using one basin or both basins.

Under normal conditions the best results were obtained when the basins were cleaned monthly. This was done by opening the waste gates of the basins and, after all the water had drained away, washing out the sludge by means of a fire hose. One basin was cleaned at a time, the work occupying three to five hours. Runs of even three months, however, can be made with excellent results unless a sudden change in the temperature of the entering water causes a rise in its density, when vertical convection currents result and the very fine sediment lying on the surface of the sludge is sure to be distributed throughout the whole basin. In such an event the bacterial content of the filter influent becomes higher than that of the raw water. In the control of the plant when the temperature of the raw water indicated a marked increase in density of the incoming raw water the filter influent was carefully watched, particularly when dealing with dirty basins. At the first appearance of an overturning, the filters were thrown out of commission and the basins run to waste until equilibrium had again been established, a matter of a very short time. This plan was found to be much more economical than attempting to handle unsatisfactory influents, and if not done the bacterial efficiency of the filters usually fell very rapidly.

During the freshets of Spring and Fall the quantity of sediment removed daily by the coagu-

high is readily seen by comparing the average bacterial content of the raw water as given in Table 2, with that of the influent in the corresponding months. The plant was not considered to be doing good work unless the basins were removing at least from 80 to 90 per cent. of the bacteria.

TABLE 1.—GRAINS PER GALLON COAGULANT USED.

	Average	Maximum.	Minimum.	Avg. Period in Coag. Basin.	Avg. Bact. per CC. in Filter Influent.
1903					
October	2.20	8.0	1.00	6.1	680
November ..	1.60	4.5	0.90	6.5	960
December ..	1.10	1.2	1.00	6.2	870
1904					
January	1.20	3.0	0.60	6.3	1900
February	1.25	3.0	0.75	5.4	500
March	1.75	4.0	0.50	5.4	3300
April	1.45	3.6	0.90	5.1	690
May	1.10	2.5	0.70	6.5	1300
June	1.60	3.0	0.75	6.3	630
July	1.60	2.2	0.95	6.6	220
August	2.00	3.3	1.20	6.1	164
September ..	1.40	3.6	1.05	6.1	129
October	1.46	2.7	1.00	6.6	430
November ..	1.33	1.9	1.20	6.6	330
December ..	1.39	2.6	1.10	6.5	400
1905					
January	0.92	1.10	0.70	—	315
February	1.20	1.90	1.05	—	195
March	1.74	3.7	1.05	—	990
April	1.44	1.9	1.05	—	285
May	1.07	1.4	0.95	24.0	175
June	1.73	2.8	0.95	24.0	470
July	2.58	9.0	1.40	13.4	785
August	1.78	2.5	1.30	15.5	175
September ..	2.03	4.3	1.20	16.3	115
October	2.73	6.4	0.90	13.6	295
November ..	1.20	2.7	0.70	13.0	325
December ..	2.80	4.5	1.30	20.0	540
Average ..	1.60	9.0	0.50	—	635

The quantity of coagulant used is also given in Table 1. It was rarely possible to reduce the rate to less than 1 gr. per gallon, while as high as 8 to 10 gr. per gallon has been found necessary for a few hours at a time to properly handle turbidities

course, obvious that failure to weigh out the proper amount or the filling of the dissolving tanks to overflowing would materially change the figures expressing the quantity applied in grains per gallon, and it was evident that such checking was imperative, since in a number of instances, the calculations did not accord with the character of the water. The plan finally adopted consisted of taking the specific gravity of the solution in the orifice tank. A large number of samples of filter alums of the type used in the plant were taken and careful determinations were made of the density of solutions of known percentage strength. From the results a curve showing the relation between percentage strength and specific gravity was plotted. A small hydrometer (of such a size as easily to be carried in the pocket) was then constructed with a scale from 1.00 to 1.06 specific gravity at 22° Cent. The corresponding percentages could then be etched upon the stem and it became merely necessary to immerse the hydrometer in the discharge tank or a sample taken from it to learn whether the solution was of the strength recorded in the day-book.

The amount of coagulant to be applied was determined in the usual manner by inspection of the amount, character and rapidity of formation

be a variable quantity, the decomposition of the aluminum sulphate being dependent upon other conditions than alkalinity alone.

The Raw Water.—Six Mile Creek is a torrential stream due to a run off exceptionally rapid; as a result the water is "catchy" to a remarkable degree. The character of the water is well shown by the analyses summarized in Tables 2 and 3. In Table 2 turbidities are expressed in terms of the silica standard; colors, in terms of the platinum cobalt standard, using the U. S. Geological Survey tubes and standard glasses; alkalinities are given as parts per million of calcium carbonate, and the bacteria as colonies per cubic centimeter on standard + 10 gelatine incubated at 20° Cent. for 48 hours. In Table 3 all results are expressed in parts per million.

During periods of drought or light rains the turbidity is very low, the bacterial content also low, the alkalinity relatively high, and fecal and putrefactive organisms are absent and the water is doubtless potable. A moderate rain, however, gives an almost immediate wash of road sides, dairy farms and several small villages; the turbidity rises with astonishing rapidity usually accompanied by a corresponding rise in bacterial counts, fecal and putrefactive organisms appear

fore a very sudden rise was so constant that it became a matter of custom to watch for it so as to learn whether an increase in the quantity of coagulant would be necessary.

The most difficult waters to treat in a satisfactory manner have invariably been those after a sudden drop in temperature following a thaw in winter and spring. Under these conditions coagulation usually is slow and the resulting flocs exceedingly finely divided. Sometimes, as already stated above, it has been almost impossible to start the reaction. Should a heavy shower be followed by a second shower the turbidity of the water rises to a value higher than before, but the bacterial content is, as might be expected, much lower than the water resulting from the first run-off. On the other hand a storm giving rise to a slow run-off followed by a heavy shower will first give a high turbidity and high bacterial count followed by a bacterial count considerably higher than that in the more turbid water. As representative examples of the character of the water and the working of the plant under these conditions the following cases may be cited:

	Raw Water.		Coagulated Water.		Filtered Water.	
	Turbidity.	Bacteria.	Per cent Bact. re. moved.	Per cent Effic. of Plant.		
Mar. 23..	140	65,000	1,200	98.1	12	99.98
Mar. 24..	500	175,000	1,200	99.3	45	99.97
Mar. 25..	1,200	56,000	500	99.1	14	99.97
Mar. 27..	200	21,600	800	96.3	45	99.79
Oct. 2..	35	4,500	30	99.3	6	99.93
Oct. 3..	1,200	14,500	450	96.6	12	99.91
Oct. 4..	500	73,000	1,080	98.5	90	99.88
Oct. 5..	200	2,000	725	63.7	65	96.75
Oct. 7..	77	10,500	450	95.7	40	99.52

Filters.—The filters are rectangular concrete tanks, 11 by 17 ft., with a sand surface 11 by 16 ft., equivalent to 0.004 acre and planned to yield at the rate of 131,000,000 gal. per acre per day. The under drains consist of a 6-in. leader 16 ft. long, in the center line, tapped on both sides at intervals of 6.14 in. by laterals of 1½-in. wrought-iron pipe. Each lateral carries 11 Continental strainers, 5.9 in. center to center, with the end strainers 3 in. from the tank walls. Each filter therefore has 682 of these brass strainers. The concrete in which the under drains are imbedded is laid up to the shoulder or flange of the strainers. Above the strainers are placed 7 in. of graded gravel ranging from 1/12 in. to ¼ in. The sand bed consists of 30 in. of sand from Felts Mills, N. Y. This sand, which has been neither sized nor screened, has an effective size of 0.39 mm., and a uniformity coefficient of 1.50. The under drains discharge through Weston controllers having a rate of 525,000 gal. per twenty-four hours. These controllers have proved satisfactory and repeated measurements have shown that their constant is substantially correct. However, the fact that their discharge is a fixed quantity has frequently proved uneconomical since three filters in service would at times cause a constant flow of the pure water basin, while only two in service would prove insufficient to supply the immediate needs. The controller of each filter is connected with a Jewell loss-of-head gauge provided with electric bell and contacts so arranged as to ring automatically when the loss-of-head of the filter reaches 9 ft., the point set for the washing of the filters.

In the washing of the filters it was found, after experimental runs extending over a period of several months, that the best results were obtained by first slowly turning on the wash water so as to lift the film of deposit lying chiefly upon the surface of the sand, and float this material off; then increase the force of the wash water to its full power. As soon as the filter showed signs of clearing, the wash water was turned off and compressed air turned on at a pressure of 3 to 5 lb. for three minutes under normal conditions, but occasionally for five minutes. After closing the air valve, washing with water was again practiced until the sand bed could easily

TABLE 2. RAW WATER FROM SIX-MILE CREEK.

Date.	Bacteria per cc.			Turbidity.			Color.			Alkalinity.		
	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.
1903												
Oct.	7,220	36,000	850	80	1800	Trace	45	128	3	81	134	45
Nov.	5,460	23,000	800	31	160	1	63	160	18	82	93	60
Dec.	2,900	8,600	900	8	35	1	33	85	14	89	98	80
1904												
Jan.	6,200	520,000	1000	13	2500	5	14	40	10	76	100	45
Feb.	13,400	97,000	1500	46	400	6	11	24	4	72	85	35
Mar.	28,600	115,000	2500	220	3000	5	13	24	5	57	88	40
Apr.	7,330	50,500	1500	104	400	40	11	20	5	54	68	38
May	7,300	35,000	450	40	500	10	13	24	5	72	95	55
June	7,500	62,000	450	47	250	7	15	34	5	94	125	60
July	1,050	6,500	350	57	95	28	9	27	3	127	130	120
Aug.	2,400	18,000	400	76	200	45	20	45	1	127	140	110
Sept.	1,200	2,800	500	57	80	18	9	20	3	131	140	125
Oct.	3,100	15,000	250	15	70	5	30	118	9	117	150	75
Nov.	1,600	3,000	350	3	8	1	18	30	10	107	115	95
Dec.	3,160	20,500	125	18	200	2	15	35	10	105	130	45
1905												
Jan.	3,600	12,000	150	25	93	4	11	18	5	70	85	45
Feb.	1,000	7,900	190	10	30	2	8	20	2	103	115	90
Mar.	30,000	175,000	550	125	1200	6	23	72	5	74	115	20
Apr.	4,380	20,500	400	37	110	8	19	45	8	57	70	45
May	1,600	3,000	500	16	25	5	9	25	4	96	110	75
June	4,840	20,000	500	54	200	13	23	90	5	96	125	70
July	7,200	36,000	1000	170	1000	22	26	65	6	128	180	95
Aug.	1,480	3,500	450	37	157	8	13	25	8	151	175	125
Sept.	16,740	180,000	220	110	500	6	10	20	3	123	150	97
Oct.	12,250	73,000	1200	316	1500	35	23	65	9	112	160	85
Nov.	4,340	49,000	250	76	260	3	23	60	10	112	127	100
Dec.	8,220	26,000	1500	174	300	100	18	20	10	93	120	76
For 27 mos..	7,150	520,000	220	72	3,000	Trace	20	160	1	96	180	20

and rapidity of settling of the flocs of aluminum hydroxide. For this purpose, samples of the raw water, immediately after the application of the coagulant, were taken at intervals in tall beakers or glasses and set aside for ten to fifteen minutes. With the waters of the character treated it was found easy to estimate the proper quantity of coagulant within a few tenths of a grain per gallon. A curve was also plotted with grains per gallon as ordinates and turbidities as abscissas according to the data from the best results obtained, to serve as a guide in estimating the proper quantity of coagulant for any given turbidity when both sedimentation basins were in service. The results given by this curve were found reliable for all save very low or very high turbidities. In most cases the addition of a trifle too much coagulant proved more objectionable than too little; the number of bacteria in the effluent increased more rapidly, the filters clogged faster and the amount of wash water required was greatly increased. The alkalinity of the raw water was at all times more than sufficient to take care of the coagulant required and at no time could undecomposed aluminum sulphate be detected in the filter effluents or filter influents, save in the case of experimental runs made with the view of learning the results of over-coagulation on filters and effluents. A number of attempts were made to learn the reduction in alkalinity due to the addition of exactly one grain per gallon, with a view of checking in this way the hourly records kept by the filter attendants. To our surprise this reduction appeared to

and the water becomes unsafe for household use. The turbidity of this stream ranges from none to over 4,000, the rising being very rapid and the fall almost equally so.

TABLE 3. AVERAGES OF PARTIAL ANALYSES OF WATER FROM SIX-MILE CREEK.

	Parts per million.
Nitrogen as free ammonia.....	0.019
Nitrogen as albuminoid ammonia.....	0.065
Nitrogen as nitrites.....	Trace.
Nitrogen as nitrates.....	1.170
Oxygen consumed.....	1.710
Chlorine.....	3.200

Frequently the turbidity rises from less than 100 to over 3,000 in less than five hours. The maximum turbidity usually persists for a few hours only, often one hour or less, it then falls gradually for a few hours, after which the fall is apt to be very rapid. A coefficient of fineness greater than unity has not yet been observed.

These waters are most interesting to handle owing to their sudden and complete change in character. The setting in of a heavy shower is marked at first by a gradual rise in the turbidity of the raw water as it enters the filter house; should the storm prove to be a violent one, there is, in about two hours, a sudden and striking clearing up of the entering water, followed in less than an hour by great and rapidly increasing turbidity. It would appear that the first rush of the run off carries into the impounding reservoir weathered clay which acts as a coagulant. The appearance and character of the water at such times seems to justify such a hypothesis. This well marked period of lowering in turbidity be-

be seen and the wash water flowing in the gutters was substantially clear. The average time required for the clearing of the filters by wash water was about seven minutes. No effort was made for many months to economize in the wash water, the only orders being "wash until the filter is as clean as it can be made." The figures for wash water used, as given in the table, are therefore maximum values.

When the air was applied first, the amount of wash water required for satisfactory cleaning was almost invariably greatly increased and the bacteriological efficiency of a filter thus washed was subsequently uniformly lower than by the method of first applying wash water, due probably to the fact that the bacteria removed by the upper layers of the filter were distributed throughout the sand bed and gravel.

The usual practice has been to place the filters on one side in service for a week, then shift to the other side; that is, filters 1, 3 and 5 would be in service while 2, 4 and 6 were lying idle, and vice versa. For several months the shifts from one set of filters to the other set, were always made on Sunday mornings, irrespective of the loss-of-head. This was done in order that certain data might be obtained and also to permit of supervising the washing. After it was found that the filter house attendants were sufficiently skilled and careful, the practice of shifting only when the filter showed a loss-of-head of 9 ft. was adopted as the normal method of procedure. Thus it happens that the percentages of wash water used, as given in Table 4, are, for the first six months, somewhat greater than that actually required.

TABLE 4. OPERATING RESULTS, ITHACA FILTERS.
MONTHLY AVERAGES OF ALL FILTERS.

	Avg. per cent. bacteria removed by all filters	Avg. bacteria per c.c. in filter effluents	Avg. quant. water filtered daily, per filter	Avg. per cent. wash water used	Avg. per cent. total waste	Avg. hours run between washings per filter	Average quantity water filtered daily in thousand gallons
1903—							
October...	99.8	26	458.2	3.2	3.6	17.1	1,550.0
November...	99.5	19	433.0	3.7	4.4	21.8	1,532.2
December...	98.9	37	452.9	3.3	4.1	19.8	1,501.6
1904—							
January...	98.1	112	427.5	3.9	4.3	22.4	1,586.6
February...	97.9	168	424.9	4.0	4.8	18.3	1,795.7
March...	99.1	153	386.1	4.3	5.4	18.7	1,815.2
April...	99.0	34	417.9	4.1	4.8	21.2	1,556.1
May...	98.3	50	446.7	3.4	4.0	22.4	1,621.2
June...	98.7	22	406.1	3.3	3.8	26.4	1,658.7
July...	96.7	30	414.0	2.7	3.3	23.7	1,582.2
August...	97.8	24	421.0	2.7	3.3	21.2	1,681.8
September...	97.9	20	373.8	4.7	5.6	12.3	1,674.5
October...	98.3	33	430.4	2.6	3.6	20.2	1,580.2
November...	97.8	32	450.9	2.6	3.0	24.6	1,553.3
December...	97.8	27	428.9	2.9	3.4	23.5	1,618.3
1905—							
January...	98.8	28	236.9	3.9	5.3	28.4	606.0
February...	99.0	7	271.0	2.3	3.6	24.4	636.7
March...	98.9	53	192.6	3.9	4.7	35.6	588.1
April...	99.4	10	193.5	5.3	6.2	48.9	489.2
May...	99.3	11	200.7	3.5	4.4	49.0	490.9
June...	99.1	35	248.4	3.4	4.3	36.0?	571.5
July...	98.3	54	284.8	2.3	3.5	37.5	736.2
August...	96.3	42	310.8	2.0	2.7	63.3	650.7
September...	99.1	5	349.4	1.2	1.6	64.1	637.9
October...	99.4	22	288.6	1.8	2.2	46.5	689.6
November...	98.8	18	287.2	2.0	2.3	38.6	735.5
December...	98.6	56	217.6				470.9

In order to learn whether the use of air in washing was essential or desirable in this plant and with waters of the type of Six Mile Creek, no air was used during the first fifteen months in the washing of either filter 3 or filter 4. At intervals the sand beds of these filters were drained and the sand removed down to the strainers for examination. At no time was there any discoloration of the sand or formation of "mud balls" or of masses of vegetable matter. No difference in the appearance or character of the sand beds as compared with the air treated beds could be detected. During this period a very noticeably less amount of wash water was required for the proper cleaning of these two filters; their bacterial efficiency was not at all impaired (as a matter of fact, their efficiencies average about one-tenth of one per cent. higher) and the average run between washings was noticeably longer. During the last six and one-half months of service, covered by Table 4, no air was used

in the washing of any of the six filters owing to the fact that the power house was damaged by a June freshet and the air compressor placed out of commission. The absence of all "mud balls" and discoloration, in spite of the fact that the raw water contains, when the turbidity is high, much blue clay and dead leaves in suspension, is doubtless due to the fact that there is a moderately long period of subsidence in the coagulating basins.

As stated above, the normal method of procedure for the greater part of the first year was to keep all even or all odd numbered filters in service for a week at a time. During this period as soon as the loss-of-head of any filter of the series in service reached 9 ft., the filter was washed and again placed in service at once.

Upon studying the efficiency of the filters it was found after some months that the effluents gave high bacterial counts immediately after the filters were washed, after an influent high in bacteria, although until the filter was washed, the bacteria in the effluent were few in number. It seemed probable, therefore, that the bacteria were not passing through the sand bed, but that during the washing the bacteria penetrated to the lower parts of the bed and into the gravel between the strainers, then when the filter was again placed in service they would slowly be forced into the under drains and thus into the effluent. These high counts in such effluents would often persist for several days and would be out of all proportion to the number of bacteria in the constantly improving influent.

It was also noticed that a filter which had been lying idle and was placed in service to handle a poor influent gave a much higher efficiency than one which had been in service with such influents, washed and again placed in service. It was evident that an entirely new system should be tried and compared very carefully with the older one. As a result of this study, whenever the raw water gave a very high turbidity and corresponding high bacterial count, and the influent would in all likelihood also soon increase in bacterial content, all filters washed were allowed to stand idle for at least one day after washing, and when possible two or even three days were allowed to elapse before again placing them in service. The results more than met our expectations. Many experimental runs were again made to learn whether such a system was always desirable. These experiments gave substantially agreeing results, in that the bacterial efficiencies were better if a very dirty filter was allowed to stand idle for twenty-four hours or more after washing, instead of being again placed at once in service. This practice was therefore followed during the last months covered in the table. When dealing with waters of average bacterial count and turbidity there appeared to be no gain in efficiency by this system, while on the other hand there was of course an increased waste due to the necessity of a longer period of rewash necessitated because of placing in service a filter which had been standing idle for some time.

During the first few months of service the time for filtering to waste (rewash) following washing was set at five minutes. After tests showed that the maximum efficiency appeared to be reached by filtering to waste for a period between one and two minutes, the plan of filtering to waste three minutes was adopted. When, however, a filter had been standing idle for several days after washing, the period of filtering to waste for from ten to fifteen minutes was always adopted, in order that all the water in the bed should be completely displaced before discharging the effluent into the pure water basin. In the summer months this was essential to prevent a bad odor or taste due to the growth of algae in the filters not in service.

There were times when it was found necessary

to place a filter in service for from eight to twelve hours a day only. The question therefore arose as to whether it was necessary to wash such a filter before again placing it in service or whether, on the other hand, the filter could be used intermittently until a loss-of-head of 9 ft. was reached, as under normal conditions for washing. Experimental runs were therefore made, from which it was learned that unless the period of subsidence in the coagulating basin was 10 hr. or more the bacteria in the filter effluents rapidly rose in numbers, from day to day, e. g., with a clean filter, Mar. 8, the effluent contained 9 bacteria per cubic centimeter, idle 12 hr. and again in service, 50 bacteria per cubic centimeter, idle for another 12 hr. and again in service, 135 per cubic centimeter, then 215 next day. Washing appeared to be essential to high efficiencies under these conditions. When, however, the period in the coagulating basin could be prolonged to 10 hr. or more, very different results were obtained, for under these conditions a filter could be successfully operated intermittently without washing until the normal loss of head was reached. With care a filter could be made to filter water for even 90 hr. before reaching a loss of head of 9 ft. In computing these runs between washings, the period is not included during which a filter was lying idle and not actually filtering water. The omission of the data for hours of service between washings for the months of April and May, 1905, is necessitated because of the impossibility of obtaining the return of one of the record books loaned during the litigation already referred to.

The shortest runs between washings occurred in September, 1904, due to a remarkable growth of an unidentified species of organism. In the last week of August it was noticed that the filters clogged rapidly and that the aluminum hydroxide appeared in the filter influents in large flakes. An examination of these flakes of hydroxide showed that they consisted of a mass of colorless filaments of an organism resembling *Crenothrix*. Day by day this organism multiplied in the coagulation basins and in the influent pipes. Any change in the rate of flow would dislodge at times felted masses as large as one's hand, the period of run between washings became shorter and shorter until within less than three weeks the filters would clog so as to give a loss of head of 9 ft. in a little over an hour or less, the initial loss of head being a little less than 3 ft. When washed the filters presented a most interesting sight, for as the wash water rose through the sand, the felted mass collected on the surface of the sand bed rose in an unbroken sheet until the gutters were reached when it would become torn into huge pieces and float away. One to three minutes was sufficient to clean a filter and the amount of water wasted was therefore not large considering the number of filters washed. For three days the plant was sorely tried, then the development of the organism appeared to be suddenly checked, and in about a week the filters were again working under normal conditions. No attempt was made to destroy the organism, as it was thought desirable to learn whether it would persist or would disappear as rapidly as it had come, and the information obtained would doubtless prove of value in the future operating of the plant. It was also thought desirable to learn the possibilities of the plant under such adverse and abnormal conditions. Had the conditions become critical it was only necessary to empty and clean the coagulation basins, since it was here that the growth took place, the impounding reservoir in the creek showing no such growth. In spite of the strain placed on the filters, owing to the rapid clogging, their bacterial efficiencies remained satisfactory, the average number of colonies in the effluents being 20, the efficiencies calculated in per cent. are low (97.9 per cent.), owing to the fact that, as will be seen in Table 2, the number

of colonies in the raw water was below the average, there being a period of drought. The organism has not again appeared, although a watch has been maintained in the hope that its positive identification would be possible.

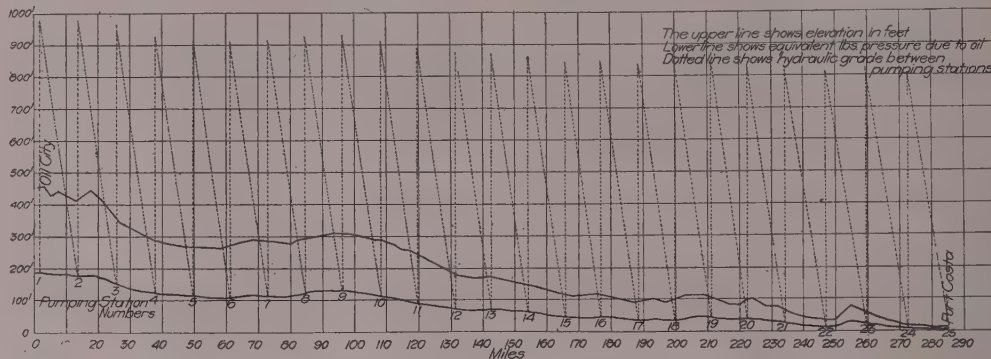
The filters have given results that more than met our expectations; during only January, February and March, 1903, have the effluents averaged over 100 bacteria per cubic centimeter, and here the high counts were the result of an insufficient knowledge of the conditions affecting the plant. Abnormally cold weather, below zero for days at a time, caught us with dirty basins and snow and ice so thick on the manholes that attempts to open them were abandoned. During a period of several hours, while shut down for freeing ice from a race way and pumps at the pump house, ice formed in the coagulation basins, and short circuits were established over the surface. The period of subsidence was thus greatly shortened, with the inevitable result of throwing too much work on the filters. The true cause of the high bacterial counts was not discovered until the arrival of sufficiently moderate weather in March allowed the inspection and cleaning of the coagulation basins and revealed ice 8 and 10 in.

water-borne diseases, it should be said that typhoid, all diarrheal diseases and cholera infantum

	Avg. for 5 years 1898-1902.	Typhoid year 1903.	Avg. for 3 years 1904-1906 Improved Supply. 184.
Total deaths from all causes...	203	269	184
Deaths of infants under five years	32	32	27
Deaths from diseases which might be directly or indirectly attributable to water supply	15	62	9

A Long Rifled-Pipe Line for Pumping Heavy Oils.

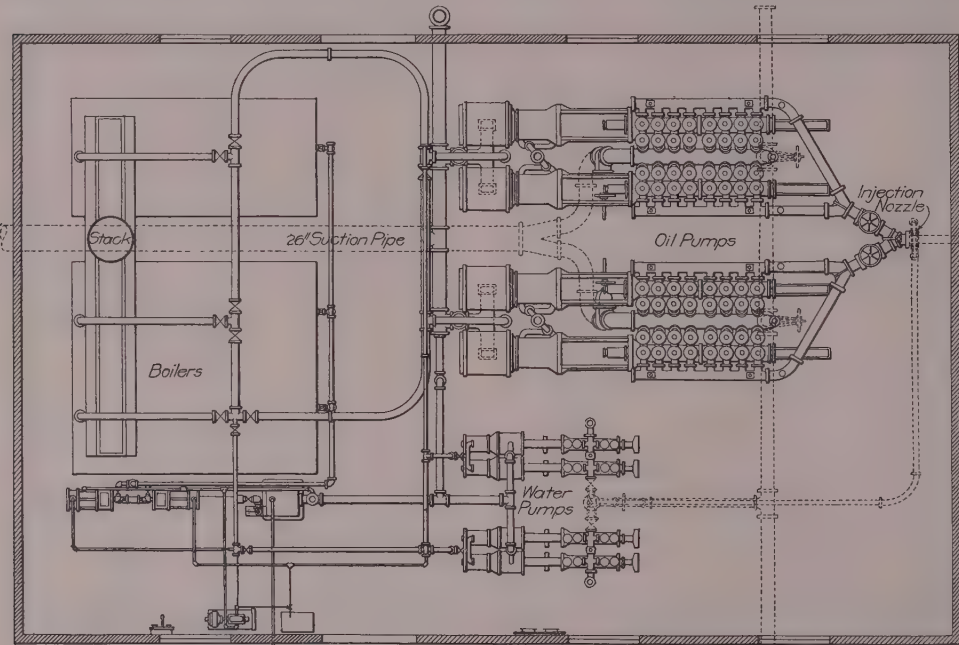
The construction for the Associated Pipe Line Co., of San Francisco, of an 8-in. rifle-pipe line extending from the Kern River oil fields in California to tide water, with a total length of 282 miles, is now approaching completion. A section of this line 31.17 miles long from Volcan, a station on the Southern Pacific R. R. in the central



Profile of Rifled Pipe Line for Pumping Heavy Oils.

part of those oil fields, to Delano, another station to the north on the same railroad, was placed in operation about two years ago. Based on the satisfactory results obtained in operating this section, the construction of the remainder of the present line from Delano to Porta Costa, the latter being on an arm of San Francisco Bay, was started in September, last, and will be ready to be put into service during the coming summer.

The oil from practically all of the California fields is a thick, heavy, viscous fluid, with an asphalt base, the output from the Kern River fields being particularly heavy, with a density averaging about 14 deg. Baume. The oil from these fields is so dense, in fact, that until recently it has been transported almost entirely in tank cars. Various attempts to handle it in long pipe lines of the ordinary type have been made, however, but these lines have not been practically successful for various reasons. In the first place, very high pumping pressures are required to push the heavy oil through such lines, resulting in large expense for pipe and for pumping equipment. Even when these high pressures are used under the most favorable operating circumstances the delivery from such lines is small.



Plan of Pump House of a Typical Station, Rifled Pipe Line.

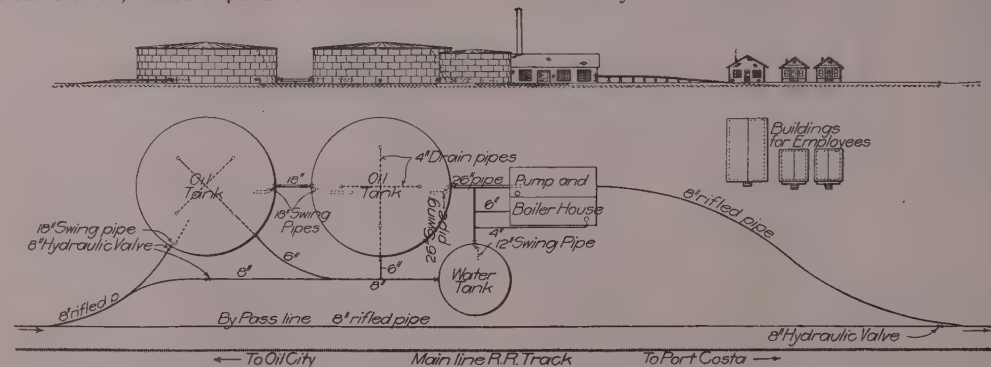
thick. In conclusion it may be pointed out that the average efficiencies of the filters during the entire period of the service was over 98 per cent. and that if we exclude from our averages such periods, where the number of bacteria in the raw water falls below 1000 per cubic centimeter, the average efficiencies will be over 99 per cent. The removal of turbidity has been complete and the color has also been substantially completely removed, no more than a trace having been found. The per cent. of wash water and of total waste has been also very satisfactory.

Only a few chemical analyses of both raw and filtered water were made; in these the removal by the purification plant was as follows: N. as free ammonia removed, 50 to 60 per cent.; N. as albuminoid ammonia removed, 50 to 60 per cent.; N. as nitrates removed, 0; oxygen consumed removed, 50 to 70 per cent.; chlorine, increased to about 5 per cent.; total hardness removed, 1 to 3 per cent.; alkalinity removed, 3 to 25 per cent.

There remains only to record the improvement in the health of the community due to the introduction of a safe and clean water supply.

In the records kept by the City Clerk it appears that the deaths in the city of Ithaca have been as shown in the table presented herewith.

In explanation of the summary of deaths from



Arrangement of a Typical One of Twenty-three Pumping Stations.

tum have been included; although doubtless the latter is probably almost wholly borne by the milk supply.

Presumably, therefore, the introduction of a clean water supply has been followed by a very material reduction in the death rate of the community.

The city of Ithaca has a population of between 14,000 and 15,000. In the typhoid epidemic of 1903 there were 1,350 cases and 85 deaths known to have resulted from an infected water supply. The writer estimates the loss to the community to have been not less than \$900,000.

Of the numerous means devised to overcome the difficulties of operating the pipe lines which have been built, the most successful has been to heat the oil. The heated oil flows much more readily than oil at normal temperatures, but so much heat must be applied, to render the process sufficiently effective to permit the location of pumping stations at practical distances apart as to cause a portion of the asphalt base to be deposited, with a consequent stoppage of the line. In some cases water is also added to the crude oil, in order to thin the latter. Since nearly 30 per cent. of water is required to produce good

results, the mixture frequently surges in the pipe line, resulting in an emulsion of water and oil that requires a temperature upwards of 180 deg. Fahr. to separate. Lighter oils mixed with the heavy oils thin the latter so they can be pumped, but the absence of the necessary light oils in fields similar to those of the Kern River preclude this method. After a long study of the existing conditions had been made and extensive experiments conducted to determine a method that would overcome the difficulties, the first 31-mile section of the rifle-pipe line was built. When this section had demonstrated in operation the feasibility of this method of pumping applied on a large scale the decision was made to extend the line to tidewater at Porta Costa.

The method of pumping in the rifled-pipe line is, briefly, to inject about 10 per cent. of water with the oil and to give the oil and water a centrifugal motion, by means of the rifled pipe, sufficient to throw the water to the outside, where it forms a thin film of lubrication between the oil and the sides of the pipe that greatly reduces the friction. In fact, the rifled pipe operated in this manner delivers at ordinary temperatures eight to ten times as much oil, net, through a long line

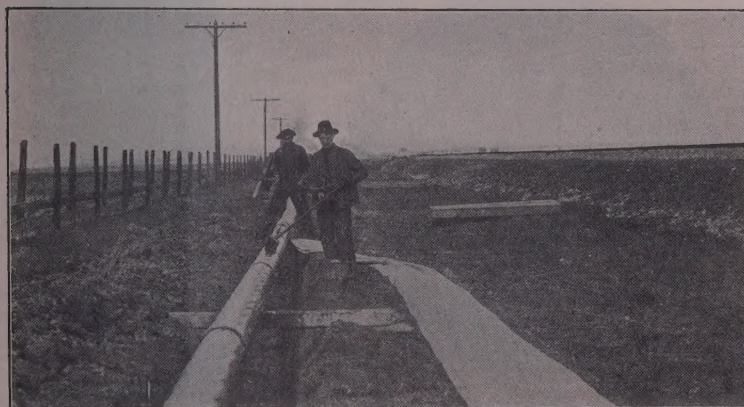
operating pressure at the pumping stations is 800 lb. per square inch. Twenty-four pumping stations, spaced uniform distances apart, are provided on the line. These stations are all adjacent to the main-line track of the Southern Pacific R. R., a siding being placed at each of them to deliver supplies. They are all arranged and equipped according to one general plan, which is shown in an accompanying illustration. The corresponding parts of the equipment in the different stations are also interchangeable, in order to facilitate construction and repairs.

Two oil pumps and two water pumps are installed at each station in a building 48 x 52 ft. in plan. These pumps are all operated by steam, which is supplied by three 250-h.p. Edgemoor oil-fired water-tube boilers in a 44 x 52-ft. building adjoining the pump house. The station in each case is on a by-pass from the main 8-in. line, although under the operating conditions the flow is always normally through this by-pass, and the main line between the ends of the latter is out of service. The by-pass delivers to a connection opening into the bottom of a 55,000-barrel steel tank, 114.5 ft. in diameter, in which the oil and water are separated by gravity. The water is

tional area of the plunger, each pot containing one valve and each pump having 32 pots built as 16 double pots. The lift of the valves does not exceed $\frac{1}{4}$ in., and the clear way opening at this lift is equal to that through the valve seat. This is the crucial feature of the entire design of the oil pumps. The valves of the latter are of the best quality of hard-wearing bronze, with seats of cast-steel.

In order to insure a steady discharge from the pumps, each of the latter is fitted with four spring-loaded compensating plungers, one on each end of the discharge manifolds. These plungers are 3 in. in diameter and have a 6-in. stroke. Another compensating plunger of the same size is placed on the Y-connection to which the two sides of the pumps deliver. Each pump is also fitted with an air chamber on the suction connection and with two 4-in. pop-relief valves designed so they can be set to operate at from 700 to 1,000 lb. pressure.

The water pumps are of the same type as the oil pumps and are designed according to the best hydraulic practice to meet the same operating conditions as the oil pumps. They have 14 and 20 x 18-in. steam cylinders, with $5\frac{1}{2}$ -in. water



Applying the Protective Coating to the Pipe.



Screwing a Joint into Coupling with Chain Tongs.

as does a line of ordinary pipe under similar conditions. The rifled-pipe line is also operated entirely without heating the oil.

The first section of the line was built of standard 8-in. steel pipe, weighing 28.2 lb. per foot. This pipe was fitted with recessed couplings and was rifled cold in the field with a machine designed specially for the purpose. As the results obtained in rifling by this method were not entirely satisfactory, owing to the injury to the pipe, the pipe for the remainder of the long line was rifled hot in the mill in which it was rolled, the same weight and size of pipe being used as before. The pipe is all rifled with six helical grooves to the circumference, these grooves making a complete turn through 360 deg. in 10 ft. of length.

The ditch for the pipe was made about 18 in. wide and 2 ft. deep throughout the entire line, except where marshy places and waterways are crossed. To provide for expansion and contraction due to temperature changes, the line was laid zigzag in the ditch within the easy elastic bending of the pipe. Traps were also formed in the pipe by laying the latter in vertical waves, 400 ft. or less, from crest to crest, the depth of these waves being about the diameter of the pipe. The water accumulates in these traps when the pumps are stopped, thus avoiding a long section of the line filled solid with oil that could scarcely be started again. The natural undulations of the ground along the location of the pipe line are such that these traps were obtained with little or no extra excavation.

The fall from Volcan to terminal tank sites at Porta Costa is about 200 ft., but practically no advantage is obtained from gravity flow, as the

drawn from the bottom of this tank by gravity through an 8-in. pipe into a 10,000-barrel tank adjacent to the pump house. The oil is drawn simultaneously from the upper part of the tank to which the line delivers, by a swing pipe arranged with a float that keeps its open end at the surface of the oil in the tank. To further separate the oil and water, the swing pipe delivers through an 18-in. connection to a second 55,000-barrel tank. The water is also drawn from the bottom of this tank into the 10,000-barrel water storage tank, while the oil is taken from the surface into a 26-in. swing pipe that forms the suction connection to the two oil pumps. The two water pumps draw from the water storage tank through a 12-in. suction connection.

The two oil pumps are of the compound duplex double-plunger pot-valve type, with the plungers externally packed. The high-pressure steam cylinders are 24-in. and the low-pressure cylinders are 42 in. in diameter, the pump having a 36-in. stroke. The steam cylinders have semi-rotary valves and are fitted with controlling valves to permit wide speed ranges to be obtained. The two high-pressure cylinders are bolted directly to the main yoke, with one low-pressure cylinder tandem to each of them. The oil end of the pumps is of the horizontal duplex double-plunger pattern, the plungers being $9\frac{1}{2}$ in. in diameter and having a 36-in. stroke. The plungers are designed for a medium working pressure of 1,000 lb. per square inch and a maximum working pressure of 1,200 lb. per square inch, with the provision they will stand a cold-water hydrostatic test of 2,000 lb. per square inch.

The valve area is 100 per cent., that is, the area of each set of valves is equal to the cross-section

plungers. The suction connections are 7 in. in diameter and the discharge connections 6 in. The water discharged by them is injected into the oil line immediately beyond the junction of the two branches of the Y-connection into which the oil pumps discharge. It is admitted through a special nozzle that throws it to the rim of the pipe and imparts a centrifugal motion to it, this motion being in synchronism with the same motion already given to the oil by the pumps which deliver the latter.

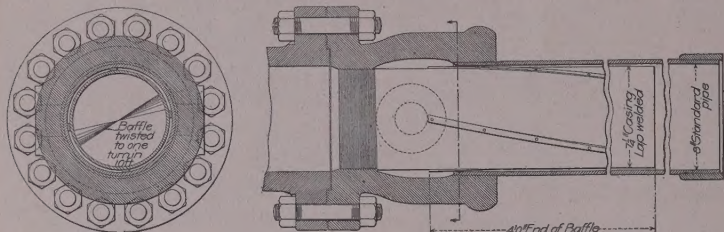
While the two pairs of pumps are in duplicate, under normal conditions all four pumps will be operated at the same time, each to about half its maximum capacity, but at its maximum efficiency. Then, in case of one pump of a pair going out of commission the other is automatically speeded up and has sufficient capacity to carry nearly the full load on the station. Under normal conditions the line will deliver 24,000 bbl. of oil every 24 hours. Since the two oil storage tanks have a combined capacity of 110,000 bbl., the line can be continued in service for $2\frac{1}{2}$ days on each side of a break. The piping connections at each station are also arranged with valves at various points, in order to permit practically any operating cycle to be obtained.

Many of the difficulties that were expected to arise in the operation of a rifled-pipe line did not materialize on the 31-mile section that has been in service for some time. Although this section was equipped with only one pumping station, the oil could be started in it with comparative ease after the pumps had been stopped. The emulsion of oil and water that occurs in a mixture of the two liquids when pumped together in an ordinary pipe was also absent. Indeed, when the oil

and water are pumped together in the rifled line all but about 1 per cent. of the water can be removed by gravity in the tanks at the end of the line. Some concern was expressed before the line was operated that the high pumping pressures required would bring the density of the oil to that of the water, resulting in a failure of the cardinal principle of the process, but such a condition has never been approached. The recesses at the joints between the sections of pipe, contrary to what might be expected, do not introduce any tendency to impede or destroy the centrifugal motion imparted to the mass of oil and water by the rifling.

In all, about 10 miles of the pipe, where the line crosses marshes and areas in which the ground-water level was above the pipe, the latter is on trestles, or a special form of pier construction. The trestles consist of two-post bents, spaced 12 ft. apart; the posts of these bents are 6 x 6-in. timbers, 5 to 20 ft. long, and are capped by a 6 x 6-in. timber. They are also each cross-braced by a 2 x 6-in. plank, and the adjacent bents are tied together by two 2 x 4-in. stringers, one on each end of the caps. The pipes are laid on the latter in a box built of 2 x 12-in. plank to protect it from the sun, as the expansion in an unprotected pipe would either break the pipe, damage the trestle, or move the pipe from the caps.

The areas in which the ground-water level is close to the surface are generally caused by seepage from irrigated land, with the result that they are filled with alkali that rapidly corrodes steel



Injection Nozzle Used to Admit Water to Pipe Line.

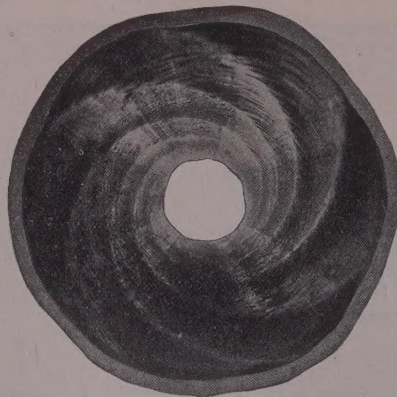
or wrought-iron. Consequently, in crossing these areas the pipe is carried above the ground on the special piers. These piers are simply boxes 2 ft. wide, 5 ft. long and 1 to 3 ft. deep, which are built without a bottom and are filled with gravel. They were used to particular advantage in isolated cases where it was impracticable to set up a pile driver.

The difficulties that have been experienced from the corrosion of other wrought-iron or steel pipes in the region in which this line is being laid have resulted in an endeavor to devise a covering for the pipe that would afford an effectual protection against such corrosion. This covering consists of a priming coat of paint made of the heavy asphalt base oil, with a proper amount of gilsonite, graphite and oil distillate added to produce the densest mixture obtainable. This coat is applied to the pipe in the trench and as soon as it is dry a second coat of paint of the same kind, with the gilsonite omitted and less graphite used, is applied. This second coat is quite sticky and over it is wrapped a strip of burlap 32 in. wide, which encircles the pipe and laps 4 in., adhering to the sticky paint. This burlap is then covered with a coat of the second kind of paint. It is also wrapped with five No. 17 annealed wires, one at each junction with the adjacent strips of burlap and three spaced between these two.

This method of covering costs much less than any other that has been used effectually. In reality, only one other method of protection has given anything like satisfactory results, which other method consists of filling the trench with oil after the pipe is laid. This method is not only expensive, with oil at 60 cents a barrel, but the oil also fails to reach the lower part of the pipe.

Seven miles of the pipe at the end of the original 31-mile line were relaid and 251 miles of new line built. After pipe laying was started in September, 1907, it was carried ahead continuously with four or five gangs having 80 to 90 men in a gang. The excavation was, for the most part, in material that could be loosened with a plow, although considerable quantities of hardpan that required picking to remove were encountered. Except in this hardpan, an ordinary four-wheel road-grading machine, drawn by 6 to 8 horses, was found to be best adapted to the work and was used to cut the trench to a depth of about 18 in. The balance of the excavation was then made and the sides of the trench trimmed to line by hand. The back-filling was also done with the road-grading machine. Working in this manner, 230 miles of pipe were laid in a little over four months, one gang having laid 4,150 ft. in one day, as a maximum.

The experiments which resulted in the adoption of the rifled-pipe pumping method were made by the Southern Pacific Co. and the 282-mile pipe line, with its equipment, now being constructed was designed by Mr. John D. Isaacs,



Interior and Exterior of a Section of Rifled Pipe.

consulting engineer of the Harriman Lines, assisted by Mr. E. E. Adams, assistant engineer. The construction is under the immediate direction of Mr. A. M. Bienenfeld, consulting engineer, of San Francisco.

The pumping equipment for the various pumping stations is furnished under contract by the Geo. A. Dow Pumping Engine Co., of San Francisco. The pipe laying was done by Messrs. Palmer & McBryde, general contractors, of San Francisco.

LARGE PNEUMATIC CAISSONS were used to construct the St. Michel station of the Paris Metropolitan Ry., one of the city subways. The station is under one of the boulevards and as the ground was water soaked, ordinary construction could not be used and shield construction was considered out of question because of the large dimensions of the station. It was decided to use three caissons sunk vertically, their total length being 390 ft. The center one, according to "The Railroad Gazette," is 229 ft. long, 55 ft. wide and 41 ft. 8 in. high, and contains the station proper. The entire caisson is on a curve of 984 ft. radius. The roof of the main portion, surmounting the working chamber, is built of arched steel trusses, forming a semi-circular section 41 ft. 8 in. wide, with a clear height of 28 ft. 3 in., which will accommodate two tracks and two platforms. The steel trusses will be entirely embedded in concrete, the total weight being 18,000 tons, of which 7,000 tons are concrete and 11,000 tons are steel. Elliptical end caissons connect with the station platforms and house the stairways, elevators and ticket office. These end caissons are sunk about 76 ft. below street level and are built with double walls, 5 ft. apart, filled in with concrete.

The Water Works System of Ottawa, Kan.

Lime and sulphate of iron are used as coagulants to assist in the removal of suspended matter and impurities from the surface supply of the recently reconstructed water-works system of Ottawa, Kan., without the settling process being followed by filters. Ottawa, with a present population of 7,500, is on the banks of the Marais des Cygnes River, a rock-bottom stream, from which its water supply is obtained. The river water is at times very muddy; but, as it is impracticable to obtain water from any other source, the works for purifying the available supply were installed. These works have been in service for 9 months, during which time satisfactory results have been obtained, although the character of the river water has varied greatly.

The original water works were built in 1886, under a franchise granted to a private company. These works included a pumping station on the river, three-quarters of a mile upstream from the limits of the city, in which station two electric generators had later been installed to furnish power for lighting and commercial purposes in

the city. The only means of clarifying the muddy river water in the original works was to pump it into two settling basins, with a combined capacity of 600,000 gal. These basins were built to operate as slow-sand filters, but were not a success, nor was their capacity adequate to provide a sufficient period of sedimentation to remove the suspended matter. As the entire equipment of the old station was also practically worn out, and as the service rendered had been unsatisfactory and the franchise of the private company nearly expired, bonds were voted in 1906 by the citizens to purchase and reconstruct the entire works. A total of \$150,000 in bonds was voted for this purpose; \$60,000 to purchase the water works system; \$65,000 to reconstruct this system; \$10,000 to purchase the electric lighting equipment and distribution system, and \$15,000 for improvements to the electric lighting system.

The river frequently overflowed into the old station, causing an interruption of the water and electric service. This hazard, together with the condition of the equipment of the old station, resulted in a decision to build a new station on higher ground, and to provide new pumping equipment and settling basins. A 10-acre tract was accordingly purchased near the western limits of the city, about three-quarters of a mile from the old station, as a site for the improvements. This tract is adjacent to a 10-in. force main leading from the old station to the city, so this main could be utilized to deliver water from new pumps at the old station to the settling basins at the new station.

A circular concrete pump pit, 18 ft. in diameter and with a total depth of 36 ft., was built on the bank of the river adjacent to the old station,

and at one side of an open suction well for the equipment in the latter. The water flows into the open well from the river by gravity through a 14-in. inlet pipe. Two vertical Worthington turbine pumps, each having a capacity of 1,750,000 gal. per day, are installed in the bottom of the pump pit. These pumps each take suction through an 8-in. pipe from the open well and deliver against a static head of 40 ft., or a total head of 100 ft., including friction, into the 10-in. force main leading to the new station. Each of these pumps is direct-connected by a vertical shaft to a 40-h.-p. 1,100-volt, 2-phase Westinghouse induction motor on a floor over the pump pit, 36 ft. above the bottom of the latter and nearly 2 ft. above the maximum flood stage of the river. These motors are arranged with a remote-control starting box, as they can be started from the new station.

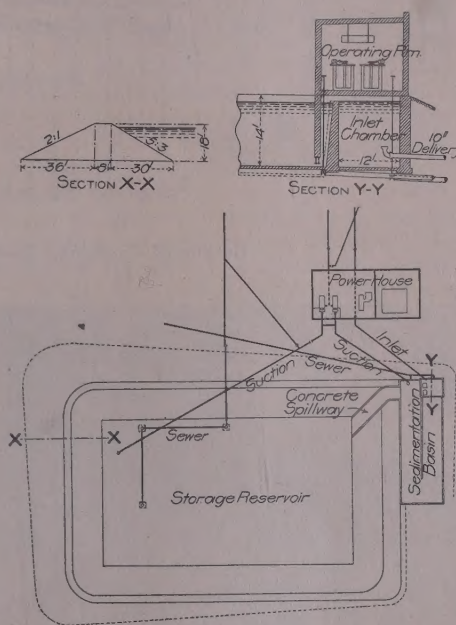
The 10-in. force main from the pumping station at the river delivers water to an inlet chamber under a coagulating house over one corner of a 450,000-gal. sedimentation basin, 41 x 120 ft. in plan. This basin is at one corner of a 5,000,000-gal. storage reservoir, 200 x 300 ft. in plan, to which water is delivered from it. The lime and sulphate of iron are made into solution in the coagulating house and are applied to the water as it enters the inlet chamber under this house. The basin is equally divided by a longitudinal baffle wall, that extends from the inlet end to within 30 ft. of the opposite end. The water leaves the inlet chamber through an opening 9 in. high that extends across one side of the chamber, the bottom of this opening being flush with the bottom of the basin. The water overflows from the basin into the reservoir at the inlet end, but on the opposite side of the baffle from the inlet chamber. The water is thus required to pass the full length of the basin twice after the coagulants are added.

The quantity of coagulants required to produce a satisfactory effluent from the sedimentation basin depends entirely on the condition of the river water. Normally, however, the amount is about 1 grain of lime and 0.5 grain of iron to the gallon. Practically all of the suspended matter is deposited in the sedimentation basin, as the latter provides for 12 hr. storage under the maximum demands on the system. The materials which collect on the bottom of the sedimentation basin are drawn out through a 12-in. drain pipe extending to a low area adjacent to the pumping station. This drain pipe is connected to a longitudinal trough in the bottom of both halves of the basin and with the inlet chamber of the latter.

The reservoir is partially in embankment and partially in excavation. The embankments are 8 ft. wide on top and have a height of 18 ft. above the bottom of the reservoir. The outer face of the embankment is built on a 2 to 1 slope, while the inner face is on a 5 to 3 slope. The maximum water line is 2 ft. below the top of the embankment. The inner slope is faced with vitrified paving brick, which are laid on edge for 12 ft. from the top, and are laid flat from that point to the bottom of the embankment. The joints between these bricks are all filled with Portland cement grout. The water flows from the sedimentation basin over a 12-ft. weir into a concrete spillway in one corner of the storage reservoir. This spillway is placed in the face of the embankment and is curved in plan to distribute the water and deliver it as quietly as possible to the reservoir. Only a small percentage of the suspended material is carried over into the latter before being deposited. The bottom of the reservoir is sloped toward one corner, however, and a sewer outlet, with three openings in sumps in that corner, is provided to flush out any materials that collect.

The new station building is a brick structure,

44 ft. 2 in. by 101 ft. 10 in. in plan, having white-stone trimmings. The interior of the building is separated into a boiler room and an engine room by a transverse brick partition wall. The boiler room contains three 66-in. by 18-ft. Brownell return tubular boilers in settings of the steel-column and I-beam type. These boilers are fired with natural gas at 25 cents per 1,000 cu. ft. for the first 200,000 cu. ft. and 10 cents per 1,000 for all over that amount. The engine room contains two 2,000,000-gal. McGowan duplex compound condensing pumping engines. A 130-kw., 1,100-volt, 2-phase, 60-cycle Westinghouse generator of the revolving-field type, direct-connected to a Russell medium-speed four-valve semi-Corliss 15 x 18-in. engine, is also installed. The original plans contemplated the removal of a 75-kw. generator and a Corliss engine from the old station, but a 125-h.-p. Weber gas engine was substituted for this steam engine. The 75-kw. unit driven by the gas engine has sufficient capacity to carry the day load on the electric lighting and power system and to furnish power to operate the motor-driven pumps at the river



Plan and Details of Ottawa Water-Works.

station. With this arrangement the gas engine effects a considerable saving in fuel as compared with the expense that would be involved in operating the steam engine.

The two 2,000,000-gal. pumps are supplied with water from the reservoir under a head of about 3 ft. through an 18-in. suction pipe extending from an inlet at the opposite end of the reservoir from the sedimentation basin. These pumps can also be supplied through an 18-in. pipe from the outlet end of the sedimentation basin. They both discharge into one main which branches just outside the station building into an 8-in. and a 10-in. line, the two lines extending to two different parts of the city. A 10 x 127-ft. standpipe floats on the distribution system and the pumps normally operated against a pressure of about 75 lb.

In connection with the other improvements 5.75 miles of new distribution mains were laid. The system of mains now embraces 8,460 ft. of 10-in. pipe; 12,280 ft. of 8-in.; 28,110 ft. of 6-in.; 31,760 ft. of 4-in.; all of which is cast iron, and 3,400 ft. of 2-in. wrought-iron pipe.

The plans for the improvements to the water works and electric lighting systems were prepared by Mr. Owen Ford, consulting engineer, of St. Louis. Mr. W. O. Myers, city engineer of Ottawa, was in charge of the construction work, and this journal is indebted to him for the notes from which this article has been prepared.

An Experiment with Calcium Chloride as a Dust Preventive.

The value of calcium chloride as a dust preventive has been tested by the Office of Public Roads on the portion of the macadam driveway in the Agricultural Department grounds, in Washington, D. C., which connects Twelfth and Fourteenth Streets. The results of the test have been made public in a bulletin of that office from which the following notes have been taken.

The roadway is built of trap rock, held in position by a soft limestone binder. The screenings of this binder pulverized rapidly under traffic, forming a light dust which passing vehicles continually raised into the air. It was then carried away by the wind. In this way the road was becoming stripped of its binding material.

In preparation for the treatment all dust and dirt was scraped from the surface of the roadway. A solution was prepared by mixing 300 lb. of commercial calcium chloride (granular, containing 75 per cent. calcium chloride and 25 per cent. moisture) with 300 gal. of water in an ordinary street sprinkler, care being taken to agitate the liquid thoroughly before applying it to insure a uniform solution. It was then applied from one sprinkling head, the sprinkler passing slowly back and forth over the road to facilitate the complete absorption of the solution. Each application consisted of 600 gal. over an area of 1,582 square yards, or 0.38 gal. per square yard.

The first application was made July 13, 1907, followed by a similar one July 15, to increase the efficacy of the treatment. The effect of the first two treatments was marked. No auxiliary sprinkling was necessary for some time, the light rains falling at intervals supplying all the moisture required. The untreated portions of the driveway lying parallel to Twelfth and Fourteenth Streets were sprinkled daily and vehicles raised a perceptible dust, although the traffic over these wings was much less heavy than that on the treated portions.

During this time the appearance of the roadway varied perceptibly in color according to the moisture in the road surface, ranging from a light gray when dry to a peculiar grayish brown when moist. The brown shades were deepest over the portions traversed by the wheels of vehicles. The texture of the road surface was completely changed after the application of the calcium chloride. Before treatment, raveling was excessive in spots and the whole surface seemed loosely knit together. After the application on July 15 this condition changed and the road surface became smooth, compact, and resilient.

The third treatment was given August 3, as certain points exposed to the most severe wear were showing signs of raveling. The phenomena following this treatment were not unlike those attending the first set of applications and repeated themselves as later applications were made, though no further treatments were given until the condition of the roadway seemed to demand it. Such auxiliary sprinkling as was necessary consisted in the application of about 0.2 gal. of water per square yard at a time.

The cost of the applications is shown in the accompanying table. The calcium chloride was donated by a manufacturing chemical company of Baltimore, Md., and is charged at the rate of \$16 per ton, f. o. b. cars at Baltimore. A freight charge of 13 cents per hundredweight is added to place the material on the ground.

TABLE SHOWING COST OF APPLYING CALCIUM CHLORIDE.	
Item.	Cost.
600 lb. calcium chloride, at \$18.60 per ton.....	\$5.58
3 men working 1½ hours, at 15 cents per hour....	0.675
1-horse sprinkling wagon for 1½ hours, at 35 cents per hour.....	0.525
Total cost of 1,582 square yards.....	6.78
Cost per square yard at this rate.....	0.0043
Total cost of five applications.....	33.90
Cost per square yard of five applications.....	0.0235

The specific gravity of these solutions ranged from 1.053 to 1.060. Some variation was un-

avoidable, as the calcium chloride in some of the barrels had absorbed a large amount of moisture from the atmosphere. In such cases the actual percentage of the chemical to 300 lb. was less than where little or no moisture had been absorbed.

At the time of the last application several hundred pounds of the salt remained unused. This was divided as nearly as possible into two parts, to be applied to the two wings of the driveway lying parallel to Twelfth and Fourteenth Streets. The east wing received a treatment of 0.28 gal. per square yard of a solution the specific gravity of which was 1.145 and the west wing a similar application of a solution having a specific gravity of 1.121. No further sprinkling was found necessary for the remainder of the season upon these branches of the main driveway.

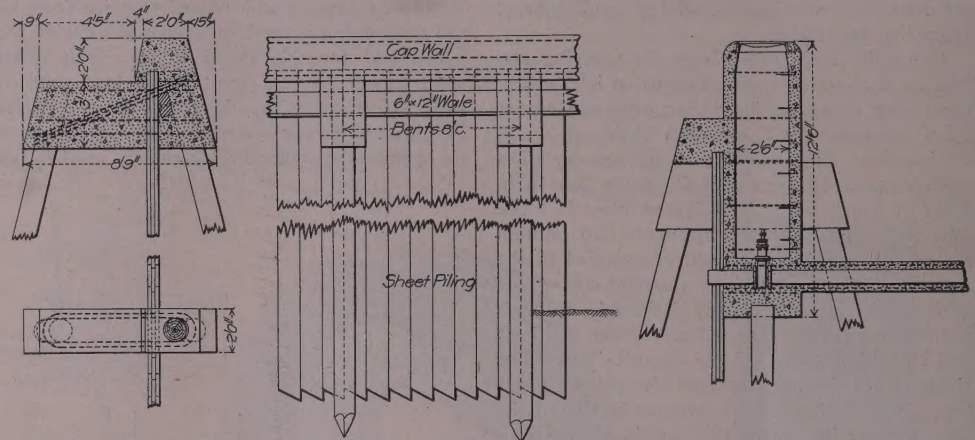
A Combination Timber and Concrete Bulkhead.

A combination timber and concrete bulkhead has recently been completed to retain the bank along one end of an artificial lake in Westlake Park, Los Angeles, Cal. The park occupies the bottom and side slopes of a draw, the channel of which in its original condition, was a flat two or three hundred feet wide, consisting of a deposit of mud of considerable thickness. The lake was formed by an embankment about 25 ft. high along one side of the park and on this embankment is an 80-ft. city street. The slope of the embankment had been built back in steps from the bottom of the lake to the street line by means of two low rubble walls. This slope below the water level was in a semi-fluid condition sufficiently

head varies between Elevations 242 and 248. The minimum level of the water in the lake is at Elevation 241.9 and a maximum high-water level at Elevation 249, the top of a cap wall on the bulkhead being placed at the high-water level. On account of a possible variation in the high-water stage, it was inadvisable to use exposed timbers for the upper part of the bulkhead. At the same time, the conditions at the site precluded any attempt to provide a footing wall extending down below the original ground surface, as was necessary to protect the embankment. The combination structure of reinforced-concrete and timber was accordingly built with the timber portion entirely buried.

The details of the design of this structure are shown in an accompanying illustration, while a

surmounted by a continuous cap wall of reinforced-concrete, which is normal to the transverse center line of the bents and on the water side of the latter. The outside row of the round timber piles of the bents, and the bulkhead of timber sheeting also extend up into this cap wall. The two piles in each bent are tied together by several steel reinforcing rods in the concrete cap of the bent. The bracing of the batter piles, on which the stability of the structure depends is thus much stronger than could have been obtained by means of tie rods and timber bracing, and the rods are protected from rust by the concrete. The bottom of the concrete ribs of the bents is below the water surface except for short intervals on rare occasions when the lake is drained out and the upper part of the timber structure is



Details of Combined Timber and Concrete Bulkhead.



A Portion of the Bulkhead before the Lake Had Been Refilled.

stiff to sustain the superincumbent earth until the lake was drained out for the first time last fall. When the water pressure due to lake when filled was removed, 120 ft. of the slope of the embankment, with the sidewalk and rubble walls dropped vertically about 4 ft.

Following the accident a decision was made to build a permanent bulkhead along the edge of the lake adjacent to the street, and to erect on this bulkhead a retaining wall of rubble masonry that would hold in place the slope of the embankment. This bulkhead and retaining wall were built on a slight curve with a varying radius, the total length of the structure being approximately 270 ft. The elevation of the original ground surface at the side of the bulkhead varied from a minimum elevation of about 227 ft. above sea level at the old channel to Elevation 247½ ft. at both ends of the work. The present surface of the embankment slope on the line of the bulk-

view of the complete work is given in a photograph reproduced herewith, taken before the lake was refilled. The bulkhead has a continuous row of triple-lap Wakefield wooden sheet piling, consisting of 2-in. plank, which are driven to a penetration of at least 4 ft. in the firm stratum of original ground under the embankment. This tight wall of sheeting is held in place by a row of wooden pile bents, the piles of which were driven to refusal through the soft mud fill, the latter varying from 10 to 20 ft. in thickness, and into the firm underlying stratum, the total penetration being 25 to 30 ft. These bents each have two batter piles and are spaced 8 ft. apart on centers. The two piles in each bent are capped by a reinforced-concrete rib 2 ft. wide and 3 ft. deep, in which the heads of the piles are imbedded as shown in the drawings. These reinforced-concrete caps of the bents are 8 ft. 9 in. long at the base and 5 ft. 7 in. long at the top. They are

also entirely protected from the decay that would be induced on account of the varying water level, if it were exposed. The low cap wall, which is reinforced with continuous longitudinal rods, provides the necessary base for the rubble masonry slope wall that is to be built to retain the face of the embankment above the top of the bulkhead.

A drainage outlet is provided through the bulkhead at one end of the latter by means of a 12-in. connection to a sewer under the adjacent street. A concrete manhole on this connection containing a gate is built into the superstructure of the bulkhead, and is tied into the concrete of the latter with reinforcement bars.

The bulkhead was designed under the direction of Mr. Homer Hamlin, city engineer of Los Angeles, Cal., by Mr. H. G. Parker, engineer of bridges, and was constructed by the Atlantic Gulf & Pacific Co., for a contract price of \$4,120.

A RAIL LOADING DEVICE capable of handling eight rails at a time has been devised for use on the Western Pacific Ry. by Mr. T. J. Wyche, division engineer. It consists of two straight bars or yokes held apart by an iron pipe separator so as to have a span a few feet less than the length of the rails to be handled. To each yoke are attached eight bifurcated hooks, the two parts of which are about an inch apart so that they straddle the web of the rail and catch under either the base or the head according to the way the rail is lifted, whether head up or head down. The hooks are strung along the yoke on heavy chains at the proper distances for piling rails in the customary fashion, one layer with heads up, and the other heads down, the latter fitting between the rails of the first layer. The device is swung from the boom of a locomotive crane, which is placed at one end of the flat car to be loaded or unloaded. The handling is done by first picking up eight rails, heads up, and placing them on the car, then following with the next lot of rails, heads down, so as to pile properly. The necessary splice bars are piled on two rails held by the hooks, and then hoisted to place.